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Dual Coding Cognition in Devising Infographics for an Enhanced Students' Scientific Knowledge

[1]Jocelyn Dogomeo & [2]John Vincent Aliazas

Abstract

The goal of science education is to increase students' scientific literacy, which includes the acquisition of scientific knowledge, to become informed and active citizens who can make decisions that influence health, environment, or society. In line with this, the study sought to determine the efficacy of using infographics in enhancing the scientific knowledge of 160 grade 8 students in Alaminos Laguna. Through descriptive developmental design, the study employs survey questionnaires to assess students' dual coding cognition, students' preference for static versus animated infographics, and experts' ratings on the designed infographic materials. The results showed that students' dual coding cognition is practiced in both verbal and imagery; both infographics were also preferred by the students. The static infographics was rated excellent while animated infographics received a very good rating from the expert evaluators. Furthermore, the infographics enhanced learners' performance and demonstrated a substantial difference between their pre-and post-test scores in terms of scientific knowledge. The findings indicate that using infographics to increase students' scientific knowledge and academic performance was indeed beneficial.

Keywords: *Animated, dual coding cognition, infographics, mental imagery, scientific knowledge, static*

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1. Introduction

For decades, scientific literacy has been a desired outcome in science education. It focuses on the acquisition and application of scientific knowledge that will impact the student's personal decision-making and public participation in science. Scientific knowledge is an important component of scientific literacy (Eilks & Hofstein, 2017). However, lack of scientific knowledge leads to poor development of scientific literacy skills which not only hamper students' personal decision making but also impedes scientific and technological advancement and country's excellence (Zainuri et al., 2020).

In 2019, the Philippine educational system was put into spotlight as the result of Trends in International Mathematics and Science Study 2019 (TIMSS) revealed that 13% of Filipino students were on the low benchmark, which means they had "limited understanding of scientific concepts and limited knowledge of foundational science facts," while 87% did not even reach this level. Prior to this, the Philippines placed second worst in the world in science in the 2018 Program for International Student Assessment (PISA) as it received a score of 357 in science, which was lower than the average of the Organization for Economic Cooperation and Development's participating countries (Rappler, 2020).

This decline in student performance is reflected in the School Level of Progress and Achievement Report of the Junior High School students in Alaminos Laguna in the school year 2020-2021. Only 11.07% of the 1,770 students received an outstanding grade of 90-100, and only 16.84% received a very satisfactory grade of 85-89, while most students received a satisfactory grade of 80-84, which is 35.76% and a fairly satisfactory grade of 75-79, which is 36.33% of the total population. Given this situation, it is imperative to exert maximum efforts to deal with these concerns among Filipino learners. One of the innovative ways to improve academic performance is to introduce strategies such as infographics in teaching science concepts.

According to Parkinson (2016), infographics combine brief explanatory text with visual symbols to convey information in an appealing and understandable way. The numerous representations that can be employed, such as bar graphs, pie charts, histograms, zoom boxes, tree diagrams, line charts, icons, and even images, enhance the impact of infographics. Feldman, et al. (2022) add that infographics facilitates the association and creation of mental representations of words that help improve learning and memory performance in both children and adults. Similarly, Guarnera et al. (2019) state that creating mental images is a common technique that are used to improve memory and comprehension. It is a process of constructing mental images when learning

new information for better recall. However, despite the promising features of these infographics as innovative instructional tools, there is insufficient research to prove their effectiveness in improving the academic performance of Filipino students in science. This gap in the research literature is addressed in this study. As such, this study investigates significant difference between the pretest and posttest scores of students in terms of scientific knowledge before and after the utilization of infographics learning tools.

2. Literature review

2.1 Infographics in education

Several researchers explored the instructional relevance of infographics in different subjects and areas. Lyra et al. (2016) investigated the effectiveness of instructional infographics in the classroom and discovered that infographics improved long-term information retention significantly more than traditional textbooks. Similarly, Sriphrom (2019) discovered that using infographics in context-based learning to improve students' scientific literacy was effective. Punzalan and Quiambao (2019) conducted the same study and used the same indicators as in PISA 2015: scientifically analyze phenomena, evaluate and design scientific investigations, and scientifically interpret and evaluate findings. The study found that using the created infographics improved student learning and can be utilized as instructional materials and teaching aids when introducing science concepts to students. Because it is a visual, electronic type of information that 21st century learners can relate to, it can also be used to increase science literacy in various schools.

Hamadi (2019) added that the use of infographics enables students to display critical thinking abilities by filtering information, drawing connections, analyzing patterns, and generalizing based on the information provided. Yarbrough (2019) supported this finding, stating that the power of visual learning is becoming evident, and visual learning environments are becoming more prominent as teachers try to manage the information overload enabled by technological improvements. Additionally, Wise and Cooper (2019) proved that visual materials can assist people of all ages organize, clarify, and simplify difficult information and build comprehension by looking at how concepts relate to one another.

2.2 Theoretical framework

The theoretical grounds for learning using infographics have been built within the frameworks of the following theories: Cognitive Load Theory, defines learning as the process of forming and processing cognitive schemas about content to be learned and storing them in long-term memory. A considerable quantity of empirical data has demonstrated the restricted boundaries of human working memory, and cognitive load theory says that instructional design must respect these constraints (Leppink, 2017; Ocampo & Del Rosario, 2022).

Mayers Cognitive Theory of Multimedia Learning provides a valid model for multimedia learning. According to this, the human cognitive system is divided into long-term memory and working memory, with the working memory being the core of the model. It is strongly limited in capacity and represents the limiting factor in the learning process. An overload of the working memory results in cognitive overload, which results in an immediate termination of the learning process. Consequently, all design principles to be derived from the Cognitive Theory of Multimedia Learning aim at reducing the cognitive load in the working memory (Makransky & Petersen, 2021).

The Dual Coding Theory (DCT), which proposes by Allan Paivio assumes that there are two distinct cognitive subsystems. One is focused on language, whereas the other is concerned with the representation and processing of nonverbal objects (imagery). It is a broad cognitive framework that encompasses both verbal and nonverbal cognition. Nonverbal imagery is concerned with nonlinguistic perceptions of reality. Because its primary purpose is the creation of mental images, it is commonly referred to as imaging. The verbal code is concerned with language. This provides the methods for message communication, encoding, and decoding. (Yui, et.al 2017).

3. Methodology

3.1 Research design

Descriptive developmental research design was utilized in the study to gather the needed data to answer the research problems. It is descriptive in nature because a survey method was employed to determine the students' dual coding cognition, level of preference between static and animated infographics and the ratings of the expert evaluators on the developed infographic learning materials. On the other hand, the developmental research design was used to develop,

design, and evaluate infographic learning materials in accordance with the criteria or standards set to be considered effective.

3.2 Respondents of the study

The samples were chosen using a simple random technique. The respondents were 160 grade 8 students from Alaminos Laguna in the Philippines who were enrolled in the modular distance learning modality. They were chosen because the researcher prepares and distributes their instructional materials and keeps track of and assesses their learning and achievement.

3.3 Research instruments

The study used a self-made questionnaire with inputs from the review of related literature and studies. A Likert scale was utilized to assess the respondents' judgments, opinions, and frequency with which a specific task or activity is performed. There were three questionnaires developed: Dual Coding Questionnaire, Students' Level of Preference Questionnaire and Expert Evaluators Questionnaire on the Devised Infographics.

The development of infographics began by referring to the Department of Education's most essential learning competencies for the third quarter. These served as the basis for choosing the topics (States of Matter, Phase Changes, Atom's Subatomic Particles and Periodic Table of Elements) that were included in the development of infographic materials. Dual coding cognition was considered on how to best represent the information through visuals and on how to properly organize the concepts and ideas to prevent information overload. Canva free web application was used to create the static infographics. After doing the static infographics, the researcher proceeded with drafting the animated infographics. The static infographics served as the template in doing the animated infographics. To add animation on images and text, create smooth transition and basic sounds, the researcher utilized the Power Point Presentation and saved it in mp4 format.

3.4 Research procedures

The researcher seeks first the validation of the expert evaluators for the comments and suggestions regarding the research instruments. After revising the instruments, the researcher proceeded with the pilot testing involving 30 students from other section. The results of the pilot testing were sent to the researcher's statistician for reliability test. After passing the reliability test, the researcher asks for the final approval of her subject specialist and adviser. Then she sent a letter

requesting the Public Schools Division Superintendent-Division of Laguna, Schools District Supervisor-District of Alaminos and to the school principal to ask for their permission to conduct this study. After securing their approvals, she proceeded to the administration of the validated research instruments.

The dual coding questionnaire and pretest were given in printed format on the first week of the 3rd quarter on the students scheduled date and time of distribution of modules. They were given one week to answer the questionnaires. On the following week, the researcher retrieved the dual coding questionnaire and pretest. This is also the start of the administration of infographic learning materials. The static infographic was distributed in printed form, whereas the animated infographic was uploaded in YouTube and its link was distributed in the students' group chat on the same day of the distribution of static infographics. The teacher kept track as to how many students watched the animated infographics by asking them to respond with a thumb's up emoji on the link if they were finished watching the video. This was the weekly routine for distributing self-learning modules and retrieving completed learning materials from students. The lesson was completed on the seventh week of the third quarter, and on the last week, the posttest was given to assess the students' understanding of the lessons. After the administration of the research instruments, all the data gathered were prepared for statistical analysis. To protect the respondents' identity and confidentiality, the names and other personal information of the respondents were withheld during the data collection, analysis, and reporting of the study results.

3.5 Statistical treatment of data

The study utilized the mean and standard deviation to analyze and interpret the results of the dual coding cognition assessment, the students' level of preference between static and animated infographic and the expert evaluators' scores on the effectiveness of the devised infographics. Frequency-Percentage Distribution formulae enable the researcher to identify the most frequent scores and identify the students' level of understanding in the pretest and posttest in each scientific knowledge components. Moreover, T-test formula was utilized to compare whether the results of the pretest and posttest scores of the students in terms of the four components of scientific knowledge are statistically different from each other.

4. Findings and Discussions

Table 1

Dual Coding Cognition Assessment

Verbal Coding							
Decoding Skills	**M**	**SD**	**VI**	**Encoding Skills**	**M**	**SD**	**VI**
I read unfamiliar words correctly.	4.26	0.66	P	I spell unfamiliar words correctly.	3.27	0.86	MP
I recall details of what I have read or watched.	4.09	0.74	P	I provide a list of key concepts or ideas from what I have read.	3.72	0.84	P
I explain accurately how graphics is related to the text.	3.82	0.73	P	I write a clear explanation how graphics are related to the text.	3.62	0.80	P
I understand what I have read or watched.	3.78	0.72	P	I provide a summary of what I have read using own words.	3.28	0.86	MP
I make accurate connections between ideas and concepts.	3.59	0.72	P	I create outline to see how concepts are related.	3.53	0.84	P
Overall Mean	3.91	0.57	P	Overall Mean	3.48	0.67	P
Imagery							
Mental Imagery	**M**	**SD**	**VI**	**Realistic**	**M**	**SD**	**VI**
I form a clear and detailed mental image of an object or scene that I read.	4.36	0.65	P	I watch video tutorials to understand difficult lessons.	4.36	0.65	P
I make mental images that resembles the real object.	4.21	0.73	P	I read books with pictures to help me comprehend the lesson.	4.21	0.73	P
I associate mental images to the things or concepts that I need to remember.	4.42	0.60	P	I pay close attention to pictures to remember the concepts easily.	4.42	0.60	P
I visualize how things should be done before actually doing it.	3.78	0.68	P	I recall the concepts easily when they are represented with pictures.	3.78	0.68	P
I create a schematic representation of things or events in my mind.	3.60	0.69	P	I look for diagrams and illustrations to realize connections between concepts and ideas.	3.60	0.69	P
Overall Mean	4.07	0.50	P	Overall Mean	4.07	0.50	P

Legend: 1.00-1.49 (Not at all); 1.50-2.49 (Rarely Practiced): 2.50-3.49 (Moderately Practiced); 3.50-4.49 (Practiced); 4.50-5.00 (Highly Practiced)

The table shows that the result of the students' decoding skills can be interpreted as "practiced." This implies that the students can regularly carry out decoding skills that range from reading words correctly, recall the details of what they have read, explain the relationship between

graphics and texts, understand what they have read and make connections between concepts and ideas. The results are consistent with Rufon (2021), which she found out that junior high school students are competent in terms of applying decoding skills such as recognizing words clearly and effectively, pronouncing words correctly, and reading words with proper pronunciation, diction, and intonation. Quick word recognition provides easy access to the meaning of the concepts they have read. This also aids in understanding and comprehending written texts which is necessary for basic knowledge awareness and understanding. According to the same author, the use of graphic organizers across the curriculum and the application of concept imagery skills continues the development of students' decoding skills.

In terms of encoding skills, the results suggest that students can regularly perform different encoding skills such as spell the word correctly, write a concise and accurate explanation, outline and provide a summary of concepts learned. This also means that students know how to put thoughts, ideas or information into symbolic forms such as words, pictures and the likes to deliver messages effectively. Velentzas and Broni (2014) explain that encoding involves the process of translating information into a message in the form of symbols that represent ideas or concepts. This process translates ideas or concepts into the coded message that the receiver can understand. Encoding skills are honed and practiced as a person tries to communicate his thoughts and ideas. Akilandeswari et al. (2015) further add that encoding skills are further enhanced by taking an idea or mental image, associating that image with words, and then speaking those words to convey a message.

The result of the dual coding cognition in terms of mental imagery reveals that students always form mental representations from perceived or remembered objects, represent a mental picture of reality, and create mental models that can aid in their cognitive processes. Klein and Crandall (2018) support this claim and state that mental imagery is a powerful concept that is widely used. According to Feldman and Greeson (2022), creating a mental image of a word can support visual reading process and writing instruction. Imagery processing has been found to be a part of the human general cognitive functioning. Mental imagery facilitates learning and memory performance in both children and adults.

On the other hand, the result of the dual coding cognition in terms of realistic implies that the students’ abilities to perceive reality or visual stimuli from the surroundings are being practiced

and applied to their learning process. These visual stimuli include videos, books, pictures, illustrations, and diagrams. Wise and Cooper (2019) state that visual materials are helpful tools for all ages to organize, clarify, simplify complex information and construct understanding through exploration of relationships between concepts. This result was backed up by Yarbrough and Coulter (2019), which states that the power of visual learning becomes apparent, and visual learning opportunities are increasing in prevalence as teachers try to manage the information overload available through improved technology (Coulter, 2015).

Table 2

Students Level of Preference for Static and Animated Infographics

Indicators	Static Infographics			Animated Infographics		
	Mean	SD	VI	Mean	SD	VI
1. improve my critical thinking	4.37	0.71	P	4.51	0.60	HP
2. improve my motivation to learn	4.26	0.72	P	4.38	0.69	P
3. make it easier for me to recall information	4.24	0.71	P	4.37	0.61	P
4. capture my attention and keep me engaged	4.26	0.69	P	4.32	0.71	P
5. help me to understand hidden relationships	4.18	0.73	P	4.31	0.65	P
6. help me to communicate what I have learned	4.31	0.69	P	4.31	0.77	P
7. help me easily understand complex information	4.31	0.68	P	4.36	0.69	P
8. help me organize information into logical groups	4.30	0.61	P	4.14	0.83	P
9. help me to easily connect new and old information	4.19	0.73	P	4.18	0.78	P
10. enable me to determine key words and concepts in text	4.16	0.74	P	4.30	0.7	P
Overall	**4.26**	**0.45**	**P**	**4.32**	**0.5**	**P**

Legend: 1.00-1.49 Highly Unpreferred, 1.50-2.49 Unpreferred, 2.50-3.49 Moderately Preferred, 3.50-4.49 Preferred, 4.50-5.00 Highly Preferred, M= Mean; SD= Standard Deviation

The result on table 2 conveys that the students perceived the use of static infographics as an important tool in improving critical thinking, motivation, recall, engagement and conceptual understanding. This was attested by the study of Ismaeel and Mulhim (2021) where static infographics prove its effectiveness in terms of providing an easier way to understand complex subjects. The result of their study asserts that static infographics allow students to visually navigate all the components at the same time which enables students to discover relationships between these components much easier and leads to improving learning conceptual processes. This may decrease cognitive load leading to simpler cognitive tasks and information processing. Therefore, the information can be retained longer in visual memory.

The data also show that animated infographics were seen by the students as an important tool in their learning process due to its ability to capture attention, improve motivation, strengthen the retention, and recall of information and present complex information in an easier manner. Dunlap and Lowenthal (2016) state that by adding subtle micro-animations such as interactive elements, pops of color, or smooth transitions help highlight information and make the infographic become more than just an informative piece of content. It also entertains the audience which in turn builds an emotional connection with them. Motion in the infographic makes the story come to life, captures emotion, and evokes curiosity. It elevates the infographic from good to great. As a result, animated infographics help in enhancing students' ability to organize information in a logical way and provide a new way of decongesting information (Fadzil, 2018).

Table 3

Expert Evaluators Ratings on the Devised Infographics

Indicators	Static Infographics			Animated Infographics		
	Mean	**SD**	**VI**	**Mean**	**SD**	**VI**
1. Design	4.68	0.38	VG	4.61	0.34	E
2. Content	4.78	0.36	E	4.78	0.36	E
3. Clarity	4.75	0.46	E	4.69	0.46	E
4. Representation	4.75	0.36	E	4.75	0.36	E

Legend: 1.00-1.49 (Poor); 1.50-2.49 (Fair): 2.50-3.49; (Good); 3.50-4.49 (Very Good); 4.50-5.00 (Excellent)

The table presents the ratings given by the expert evaluators in the created static and animated infographics. In terms of design, static infographic got a verbal interpretation of "excellent". From the result, it can be inferred that the overall design of static infographics has met the necessary requirements to be classified as excellent. These include the use of colors that added aesthetic value and compliments with the overall design of the infographics, strong use of visual elements such as images, pictures and illustrations that emphasizes the concepts presented. Naparin and Saad (2017) defines an excellent infographic as consisting of a good title, suitable graphs, charts, pictures, images, readable text, font and have an excellent use of color and an appropriate design format. On the other hand, animated infographics obtained a verbal interpretation of "very good". This implies that the overall design of the animated infographics was perceived by the evaluators as commendable and that the fonts, colors, layout, imagery, motions, and animations complement each other and provide a great way of visualizing the information it contained.

In terms of content, both types of infographics gained a verbal interpretation of “excellent”. The scores given by the evaluator showed that the generated infographics are thought to be of high quality in terms of logically organized contents, suitability of the terminology and vocabularies employed, and simplicity of the contents. By presenting concepts in a way that ranges from simple to complex, logical organization of the content is demonstrated. Links between concepts and ideas are also made clear so that the reader will easily find patterns and connections between concepts presented. Furthermore, the terminologies and vocabularies used were chosen to be within the students' comprehension level and will be easily decoded.

Likewise, the table also indicates that the criteria set in ensuring the clarity of the developed infographics were all achieved and exhibited in an exceptional way. This also mean that the infographics present the concepts and information in a straightforward, succinct, and clear manner, without the use of graphics or other visual elements that can impede the flow of information or cause misunderstanding.

Additionally, the result of both static and animated infographics in terms of representation implies that design elements, visuals and illustrations used best fit for their purpose of representing information for better comprehension. It also suggests that the criteria to be considered excellent in terms of representations given were all met.

Table 4 shows the frequency distribution of the pretest and posttest scores of the grade 8 students. In terms of recognizing scientific terms and concepts it can be gleaned from the table that students were able to quickly recognize scientific terms and concepts after the utilization of infographics. This also mean that their scientific vocabulary improved. This is attributed to infographics' ability to draw attention to important details and information and present it in a more engaging manner. The study of Ortiz and Aliazas (2021) validated this findings and state that infographics present difficult data or concepts into straightforward, easy, and aesthetically beautiful styles which in turn encourage active participation in the data-collection process that improve retention and recall.

Table 4

Students Pre-test and Posttest Scores on Scientific Knowledge

Score	Recognize Scientific Terms and Concepts				
	Pre-test		Posttest		VI
	F	%	F	%	
90 and above	-	-	144	90	Outstanding
85-89	-	-	16	10	Very Satisfactory
80-84	10	6.25	-	-	Satisfactory
75-79	122	76.25	-	-	Fairly satisfactory
74 and below	28	17.5	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	
	Describe Scientific Terms and Concepts				
Score	**Pre-test**			**Posttest**	**VI**
	F	**%**	**F**	**%**	
90 and above	-	-	124	77.5	Outstanding
85-89	-	-	36	22.5	Very Satisfactory
80-84	8	5	-	-	Satisfactory
75-79	100	62.5	-	-	Fairly satisfactory
74 and below	52	32.5	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	
Score	**Relate Scientific Terms and Concepts**				
	Pre-test		**Posttest**		**VI**
	F	**%**	**F**	**%**	
90 and above	-	-	62	38.8	Outstanding
85-89	-	-	85	53.1	Very Satisfactory
80-84	-	-	13	8.1	Satisfactory
75-79	57	35.6	-	-	Fairly satisfactory
74 and below	103	64.4	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	
	Explain Phenomena Scientifically				
Score	**Pre-test**		**Posttest**		**VI**
	F	**%**	**F**	**%**	
90 and above	-	-	47	29.4	Outstanding
85-89	-	-	98	61.3	Very Satisfactory
80-84	-	-	15	9.4	Satisfactory
75-79	38	23.7	-	-	Fairly satisfactory
74 and below	122	76.3	-	-	Unsatisfactory
Total	**160**	**100**	**160**	**100**	

In terms of students' ability to describe scientific terms and concepts, it can be seen from the table that after the use of infographic learning tools, the students achieved an outstanding performance in their posttest, which means they can accurately describe concepts and ideas. This is due to the infographics' ability to combine meaningful visuals to text that enable the students to process them efficiently. According to Oranç and Küntay (2019), research has shown that when facts are combined with interesting images, people are much more likely to understand and remember the materials. Also, a good visual will motivate learners and improve comprehension.

Furthermore, it can be observed that students' ability to discover patterns and create meaningful connections between concepts and ideas presented are enhanced. This is due to the fact that infographics make it simple to present massive amounts of complex data, effectively deliver a message by associating pictures to highlight ideas and concepts and allow students to draw connections and see patterns in the data to make their learning more effective. Wise and Cooper (2019) findings state that infographics are helpful tools for all ages to organize, clarify, simplify complex information and construct understanding through exploration of relationships between concepts.

The result also suggests that there is a considerable improvement in students' ability to apply concepts learned to explain and predict observations of the natural world. Knowing how to apply this understanding efficiently in scientific investigations and in practical reasoning could make abstract ideas more accessible and relevant to students' learning. According to Hamadi (2019), the use of infographics helps the students to demonstrate critical thinking skills by filtering information, establishing relationships, identifying patterns, and generalizing ideas based on the facts presented.

Table 7

Pre-test and Post-test Scores of Students

Scientific knowledge	Pre-test		Posttest		T	df	Sig. (2-tailed)
	M	SD	M	SD			
Recognize scientific terms and concepts	4.39	1.69	15.09	1.09	81.74	159	.000
Describe scientific terms and concepts	4.35	1.67	14.44	1.31	-81.81	159	.000
Relate scientific terms and concepts	3.14	1.42	12.84	1.57	-82.75	159	.000
Explain phenomena scientifically	2.59	1.31	12.52	1.63	-79.777	159	.000
Overall	12.52	5.02	54.88	4.13	-154.78	159	.000

Legend: $p > .05$ (not significant); $p \leq .05$ (Significant)

Table 7 shows that there is a significant difference between the pre-test and posttest performance of the students in scientific knowledge in terms of recognizing, describing, and relating scientific terms and concepts and explaining phenomena scientifically. This significant difference implies that the use of infographics is effective in enhancing scientific knowledge. This outcome can be attributed to infographics' capabilities in providing detailed information with visual representation which in turn improves the students' ability to learn and increase memory retention. Additionally, these visual cues motivate students to learn and acquire knowledge,

organize thoughts, and discover meaning and relationships and apply this knowledge to explain scientific phenomena.

The findings of Damyanov and Tsankov (2018) demonstrate the importance and effectiveness of infographics in the teaching and learning process. By using images to strengthen the pupils' visual system's capacity to recognize patterns and trends, it enhances cognitive ability. Compared to written or spoken text, pictures and visuals help students learn and recall information more quickly and effectively. This benefit is increased when text and visuals are mixed, and students are given greater opportunities for interaction and involvement.

This also agrees with the dual coding theory that stated that presenting information through multimedia facilitates knowledge construction in a learner's mind by making connections between the various forms of information (verbal and non-verbal). Presenting information this way helps transfer knowledge to the learner's memory in multiple forms, which then can be retrieved easily and in more than one way (Ismaeel & Mulhim, 2021).

5. Conclusion

Infographics allows the teacher to offer an innovative, attractive and convenient way of delivering lesson. Based on the results of the study, the following conclusions were drawn: infographics were useful in terms of improving academic performance in science among learners; infographics are effective in enhancing the student's scientific knowledge in terms or recognizing, describing and relation scientific terms and concepts and explain phenomena scientifically; both animated and static infographics were preferred and regarded by the students as an important instructional tool. In addition, there is a significant difference between the mean pre-test and posttest scores of students who are exposed to the use of infographics on all its components, thus the null hypothesis was not sustained. Future researchers may explore the effectiveness of using infographics to different grade levels and other subject areas. They may consider studying the effects of different types of infographics in students' level of achievement.

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Profile, Patterns of Intake and Perceived Side Effects of Over-The-Counter Non-Steroidal Anti-Inflammatory Drugs

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Abstract

One of the ways in which body pain can be relieved is by medications which are readily available. Over-the-counter Non-Steroidal Anti-inflammatory (OTC-NSAIDs) drugs are the most common for this purpose. However, OTC-NSAIDs are associated with side effects that range from mild to serious. In this context, the study aims to determine the profile of the respondents and their patterns of intake of OTC-NSAIDs and its perceived side effects. A descriptive type of research was utilized to profile the 90 respondents selected through purposive sampling technique. Majority of the respondents were female, with age groups are 40 and above and 40 and below and are mostly employed. The respondents' intake of the OTC-NSAIDs were according to the most frequent causes namely: headache, backache, body ache and shoulder pain. The study revealed generic mefenamic acid, 250mg as the medication taken for up to two days or after the pains eased to which the duration of intake lasted up to 6 months only, though there were respondents whose duration of intake lasted for 1 year or longer. Although there were side-effects such as drowsiness/sleepiness, abdominal pains due to acidity, dizziness, and mild diarrhea being experienced, most of the respondents depend on the non-steroidal anti-inflammatory drugs to relieve the pains they experienced.

Keywords: *dosage, intake, NSAID, OTC, pattern, side effects*

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1. Introduction

Optimum health is a prerequisite to being able to perform everyday tasks. It is foreseen as the absence of any manifestation of handicapped or irregularities including pain. Pain may be perceived differently depending on the threshold or tolerance of a person. However, the presence of pain, regardless of the origin, denotes alteration in the full functional potential of the individual. With the bothering effects, a person cannot perform the expected task and will look for pain relievers to augment the discomforts. These pain relievers can give immediate relief with the ultimate purpose of reducing the pain and the inflammation of the affected body part. Bothering pain may be categorized as mild to moderate such as migraine, dysmenorrhea, arthritis, sprains, muscle pain, headache, and toothache. The longer the pain persists, there are chances the affected person will take the drugs whenever necessary in order for the pain to feel alleviated.

Over-the-counter (OTC) drugs are medicines that are readily available for purchase, even without prescriptions. These are classified as Non-Steroidal Anti–Inflammatory Drugs (NSAID), which include analgesics like Ibuprofen (Advil, Alaxan), Naproxen Sodium (Flanax), Mefenamic Acid (Ponstan, Dolfenal, Panadol), and Aspirin (Bayer). These drugs are available in various milligram preparations. The use of these drugs is possible without a prescription, thus considered as self-medication. Self-medication is the selection and use of medicines to treat self-recognized and self-diagnosed conditions or symptoms (Ruiz, 2010).

The availability and accessibility to more drug stores made it possible for the more convenient purchase and consumption of any OTC drugs, and this could be done repeatedly with the recurrent appearance of symptoms. However, this is not safe due to the potential health risk of self–medication practice, and not to mention, the risk to adverse effects that could be experienced after prolonged use of these drugs, may it be for short term or for long term duration. Some of the untoward effects are hypertension, palpitations, congestive heart failure, edema, gastrointestinal complications, and kidney problems.

This study intends to explore the patterns of intake of OTC-NSAID of the respondents and specifically sought to answer the following:

1. What is the medical history of the respondents in terms of the existing body parts associated to perceived pain and involvement of seeking medical consultations?
2. What is the given respondent’s diagnosis upon seeking consultation?
3. What is the usually affected body part of the respondent when taking pain relievers?

4. What is the NSAID pain reliever that the respondent is taking in terms of type, dosage, brand, number of tablets/capsules per day, number of days of intake and duration of intake of the pain reliever?
5. What is the source of information that convinced the respondents in using the NSAID?
6. What is the usual means of acquiring the NSAID?
7. What are the perceived side effects of the OTC-NSAIDs?

2. Literature review

NSAIDs are medications that relieve or reduce pain and the most popular examples are ibuprofen and aspirin. These are taken for less severe types of pain that result from problems involving aches, painful cramps, those that involves fever and swelling or inflammation (MacGill, 2017). Moreover, these drugs have been used for many years as an analgesic, anti-inflammatory, and in the case of aspirin, antithrombotic. The use of these drugs can also be expected to increase due to the increasing age of the population as well as new and developing indications thus important to assess the safety and side effects (Russell, 2001).

Medical experts agree that for most people there is no harm in taking NSAIDs for the occasional headache, fever, or muscle ache. Indeed, on any given day, millions of Filipinos use NSAIDs to soothe their daily discomforts. But these useful pain relievers also raise the risk of ulcers and heart problems in some people. NSAIDs are a common class of over-the-counter and prescription painkillers, and should never be taken regularly without discussing things with the doctor. Most over-the-counter painkillers should not be used for more than 10 days except aspirin (The painless truth about NSAIDs, 2009). Furthermore, preventable adverse drug reactions are responsible for 10% of hospital admissions among older people and NSAIDs are responsible for 30%of hospital admission (Davis et al., 2011). However, older persons, those who are taking anticoagulants, and those with a history of upper gastrointestinal tract bleeding associated with NSAIDs are especially at high risk. Although aspirin is cardio protective, other NSAIDs can worsen congestive heart failure, can increase blood pressure, and are related to adverse cardiovascular events, such as myocardial infarction and ischemia (Heintzman et al., 2009).

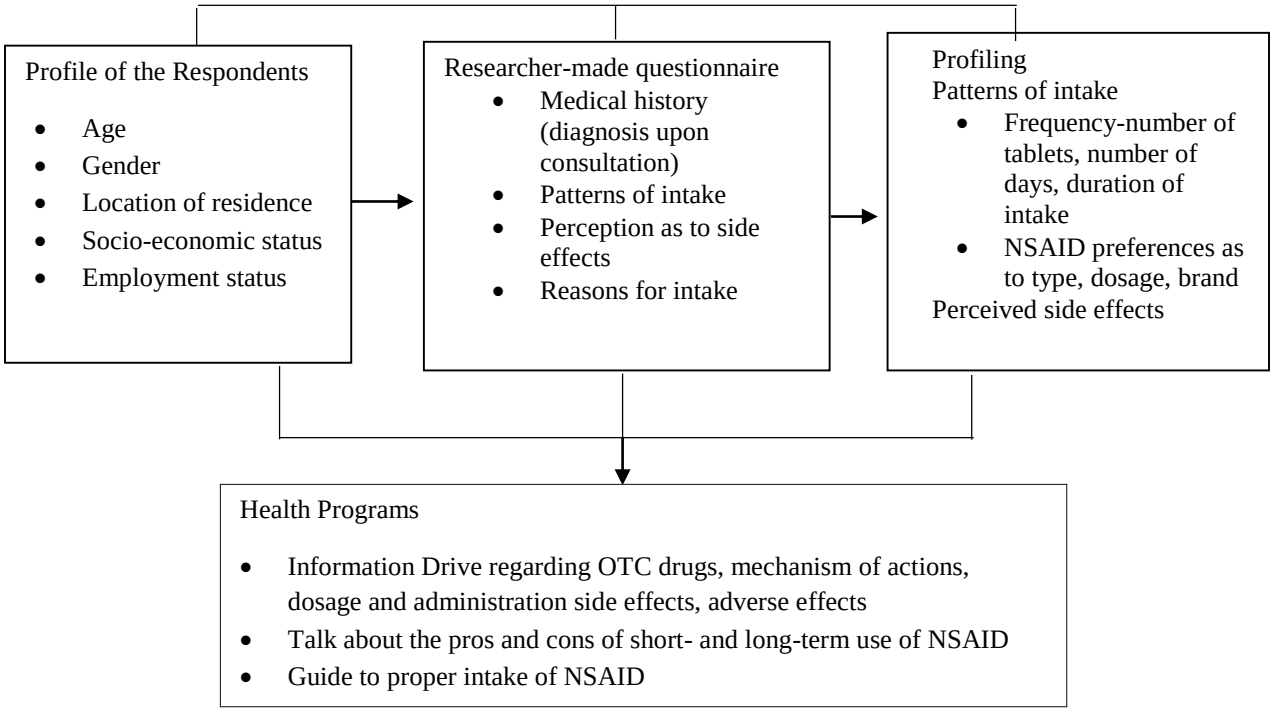
Moreover, it was one of the most commonly prescribed pain medications, a highly effective drug for pain and inflammation. However, these are known to have multiple adverse

effects on one's health condition which includes gastrointestinal bleeding, cardiovascular side effects, and NSAID induced nephrotoxicity (Wongrakpanich, 2018).

A study revealed that increasing consumer awareness of the need to consider potential risks prior to taking OTC analgesics is a positive sign. However, this is not translated to an increase in the appropriate use of the OTC-NSAIDs since it has become readily available to pharmacies and fewer people are paying attention to the literature. Since OTC analgesics including NSAIDs are frequently and inappropriately taken, the need for educational intervention in the consumption of such drugs towards both physicians and patients appears warranted (Stosic, 2011). It is therefore the intention of the study to determine the prevalence of the use of OTC-NSAID, the pattern of use, medical history, perceptions, and reason for intake among the selected respondents.

Figure 1

Research Paradigm



The research paradigm shows the input, process and output. The input is set in determining the profile of the respondents in terms of age, gender, location of residence, socio-economic status, and employment status. A researcher-made questionnaire was utilized to provide the data needed

for this study. In relation to the profile, the respondents' medical history and their patterns of intake of OTC-NSAIDs were also considered. The medical history particularly pertains to the diagnosis obtained upon consultation with a medical expert and a prescription of NSAIDs was given. The data gathered entails an appreciable view of the profile of the respondents, their patterns of intake and the perceived side effects of OTC-NSAIDs. The results will be subsequently used as a basis to formulate a health information drive. This will be part of the extension program of the Biology Department under the College of Arts and Sciences of the San Pablo City Campus.

3. Methodology

This paper is descriptive research that uses purposive sampling technique, and is limited to residents of San Pablo City, Laguna. The sampling technique used in the study allowed the researchers to select only those who are using OTC-NSAIDs. A preliminary survey was conducted to determine the OTC-NSAIDs user whose duration of intake are six(6) months and onwards to 200 respondents. Out of the 200, only 100, 50 whose location of residence are in the barrio and 50 from the city proper were given the final survey questionnaires and were included as the respondents of the study. The study was able to retrieve a total of ninety (90) survey questionnaires, 47 from the barrio and 43 from city proper.

Researcher-made questionnaires for both the preliminary and final survey were utilized and administered using Google Forms through email and Face book messenger. The respondents were given assurance that medical information provided are information resource only and not to be used or relied on for any diagnostic or treatment. The survey questionnaire used in the study only required the respondents to select applicable answers from objective response questions. The indicators included in the questionnaire comprises of socio-demographic profile, medical history, patterns of intake, reasons for intake and side effects. The Frequency and Percentage were used as the statistical tools in profiling the respondents in terms of their patterns of intake and perceived side effects of over-the-counter non-steroidal anti-inflammatory drugs or OTC-NSAIDs.

As to the profile of the respondents, Table 1 shows the selected city proper and barrio residents of San Pablo City included in the study. Among the ninety respondents, 71.1% were female, 25.6% were male, and 3.3% came from the group of LGBTQ+. The highest percentage of females may attribute to their interest in answering the questionnaire since they are more vulnerable to sickness compared to males especially when they age. The low frequency of LGBTQ+ acquired randomly.

Responses from two age groups, 40 and below, and 41 and above are well represented, having a frequency percentage of 52.2% and 47.8% respectively. It is said that age-related changes in pain sensitivity is inconsistent (El Tumi, 2017). This suggests that both age groups are bothered by their pains and take anti-inflammatory drugs. Likewise, regardless of where they reside, in the city proper or in the barrios, 47.8% and 52.2%, both groups were to take anti-inflammatory drugs whenever they are in pain. Hence the reassurance of preventing and abating pain before it even occurs, the tendency of one to stock or restock pain relievers becomes necessary regardless of the respondents' place of residence.

Table 1

Socio-demographic Profile of the Respondents

Profile of the Respondents	Frequency	Percentage
Gender		
Male	23	25.6
Female	64	71.1
LGBTQ+	3	3.3
Age		
40 and below	47	52.2
41 and above	43	47.8
Location of Residence		
City Proper	43	47.8
Barrio	47	52.2
Socio-economic status		
Php 15,000 and below	33	36.7
Php 16,000 and above	57	63.3
Employment status		
Employed	45	50.0
Self-employed	14	15.6
Unemployed	31	34.4

n = 90

Most of the respondents made their lives easier as 63.3% have an income higher than sixteen thousand pesos while only 36.7% have an income of below fifteen thousand pesos. Fifty percent of the respondents were employed, 34.4% were unemployed and only 15.6% were self-employed. A study suggested that when someone from a workplace experiences pain, it may lead to loss of productivity due to

absenteeism (Adams, 2021). In addition, one tends to have lesser income due to inability to work as a consequence of pain.

4. Findings and Discussion

The subsequent results are presented and discussed with reference to the aim of the study and that is to determine the medical history of the respondents, patterns of intake of over-the-counter non-steroidal anti-inflammatory (OTC-NSAID) drugs and its perceived side effects.

1.1.Medical History of the Respondents

The medical history of the respondents was also considered in the study. This was limited the existing body parts associated to perceived pain and involvement of seeking medical consultations.

Table 2

Body parts associated to perceived pain

Perceived pain	Frequency	Percentage
Headache	68	75.56
Backache	57	63.33
Body ache	42	46.67
Shoulder pain	40	44.44
Toothache	33	36.67
Leg pain	27	30.00
Joint pain	15	16.67

Table 2 depicts the frequency distribution of respondents' body parts associated to perceived pain as medical conditions. People normally have reasons why they take OTC-NSAIDs. Respondents perceived and identified several types of pain which they addressed by taking OTC-NSAIDs. Among the ninety (90) respondents, who gave multiple answers on their perceived pains, 68 (75.56%) frequently have headaches, 57 (63.33%) backaches, 42 (46.67%) for body ache, 40 (44.44%) for shoulder pain, 33 (36.67%), for toothache, 27 (30.00%) for leg pain, and 15 (16.67%)

suffer from joint pain. Most of the respondents are having headaches, backaches, body aches, and shoulder pains, these conditions usually seen from the respondents who were employed (50%) and self-employed (15.6%) and considered to be work-related pains. The impact of headache calls for intervention in the workplace not only to promote a prompt diagnosis of the different forms of headaches but also to improve work organization (Magnavita, 2022). As to back pain, Iker (2019) stated that 20% were told by a health professional that their pain was work-related. Regardless of cause, low back pain can affect a person's ability to perform work tasks.

Table 3

Involvement of Seeking Medical Consultations

	Frequency	**Percentage**
Consultation with a Doctor	50	55.6
Do not seek consultation with a doctor	35	38.9
Cannot recall if seek consultation with a doctor	5	5.6
Total	**90**	**100.0**

Table 3 presents the frequency distribution of respondents' medical histories in terms of medical consultations. It is also natural that anybody experiencing pains seek medical advice as 55.6% consult with their doctors whenever they have it. But there are 38.9% who do not consult with their doctors and instead take self-prescribed drugs such as anti-inflammatories. Still, there were 5.6% who do not recall if they were able to consult, maybe they did not really seek medical advice, and just like those who do not meet with their doctors, practice self-medication. Doomra and Goyal (2020) revealed that NSAID and self –medication frequently for the relief of pain and inflammation and that patients may procure and take easily without any prescriptions. The need to consult a medical practitioner so as to determine the type of OTC-NSAID to be taken for the affected body part. However, a continuous use of OTC-NSAID for more than 3 days for fever and 10 days for pain is not recommended unless advised by a doctor who will monitor the possible side effects. Moreover, if the ongoing prescribed OTC-NSAID is not effective, then the doctor may prescribe a new medication. (Cleveland Clinic, 2020).

1.2. Diagnosis Upon Seeking Consultation

Table 4 shows the frequency distribution of respondents' diagnoses among those 50 respondents who seek consultation. There were respondents who have more than one existing condition. There were 33 respondents who have indicated an answer of mostly associated with respiratory-related symptoms. There were 11 respondents who have gastrointestinal problems, who needed to consider certain precautionary measures in taking OTC-NSAIDs. Moreover, there are also diabetics and those with cardiovascular and kidney problems which requires extra care when it comes to intake of OTC-NSAIDs giving due considerations on the possible side effects if not properly taken.

Table 4

Respondent's diagnosis upon seeking consultation

Diagnosis	Frequency	Percentage
Respiratory related symptoms	33	66
Gastrointestinal problems	11	22
Hypertension	10	20
Cardiovascular problems	3	6
Kidney problems	1	2
Diabetes	1	2

The pain experience may be relevant to respiratory-related symptoms. OTC-NSAIDs are widely used to treat common cold associated with pain and fever. Though some others are still due to gastrointestinal problems and hypertension, who commonly experience backache and headache (Meneghetti, 2020). Thus, when OTC-NSAIDs are used regularly over an extended period of time, as is often the case with chronic pain, the potential for side effects increases. (Jacques, 2022). Individuals with existing conditions who sought consultation require to have regular monitoring from their attending physicians.

1.3. Pain Reliever Use

Table 5

The affected body parts that cause the respondents to use pain relievers

Affected Body Parts (Cause)	Frequency Percent	Percentage
head	53	58.89
back	45	50
body	33	36.67
shoulder	28	31.11
joint	10	11.11

Table 5 shows the frequency distribution of respondents' affected body parts that cause the respondents to use pain relievers. The respondents identified more than one affected body parts which they treated with OTC-NSAIDs.

Pain relievers are commonly taken whenever they are experiencing pain. Most of the respondents take pain relievers if they are experiencing pain in their heads with a frequency of 53 and a percentage of 58.89%. Almost everyone gets headaches and usually disrupts one's activity (Mayo clinic, 2019). The best way so as not to hamper their activities during headaches is to take medicines.

1.4. Non-steroidal Anti-Inflammatory Drugs (NSAID) Pain Reliever Use of the Respondents

1.4.1. Type of Pain Reliever

Table 6

Type of Pain Reliever

Type of Pain Reliever	**Frequency**	**Percent**
Mefenamic acid	38	42.2
Ibuprofen	30	33.3
Diclofenac	16	17.8
Celecoxib	4	4.4
Naproxen	2	2.2
Total	**90**	**100.0**

Table 6 shows the frequency distribution of OTC-NSAID pain reliever type the respondents are taking. There are a lot of pain reliever drugs available in the market and one is the non-steroidal anti-inflammatory drugs. Most of the respondents take anti-inflammatory drugs such as mefenamic acid and ibuprofen which have a frequency percentage of 42.2% and 33.3%, respectively. Among the OTC-NSAIDs, prescription doses of Ibuprofen have greater antipyretic and analgesic effects in both children and adults compared with commonly used doses of acetaminophen (Masaleuskaya, 2015). Both the branded and the generics are easily accessible as they are greatly available in both public and private pharmacies (Batangan and Juvan, 2009).

1.4.2. Dosage of Mefenamic Acid intake

Table 7

Intake of Mefenamic Acid Dosage

Brand Name of Mefenamic acid	Frequency	Percent
Ponstan 250	4	4.4
Ponstan 500	7	7.8
Dolfenal 250	6	6.7
Dolfenal 500	9	10.0
Generic 250	39	43.3
Generic 500	25	27.8
Total	**90**	**100.0**

Table 7 shows the frequency distribution of intake of Mefenamic Acid dosage. In terms of dosage of pain reliever, mostly take 250 mg of mefenamic acid, and do not pay attention to the brand, since generics are less expensive. Ponstan and Dolfenal, at 500 mg dosage is more frequently taken than the 250 mg. The higher dosage is more preferred than the lower dosage, which may imply that consumers do make sure that with the price they pay, they could surely get well. Batangan and Juvan (2009) stated that overall indicators show that key essential medicines.

1.4.3. Brand Names of Ibuprofen, Naproxen, Celecoxib and Diclofenac Used

Table 8 displays the frequency distribution of NSAID pain reliever, various brands of ibuprofen, naproxen, celecoxib and diclofenac that respondents are taking.

As to the brand, price is a major concern. From the table, generic drugs are more frequently bought and taken. Though Ibuprofen, Alaxan, and Advil brands are more frequently bought, they may consider as fast-moving brands compared to others like Flanax and Celebrex. Likewise, the price of Flanax and Celebrex is quite high. Moreover, as to Diclofenac, generic is also cheaper than the branded like Voltaren. While many of the respondents chose any brand will do for them, which may account for the drug that is readily available from the store/pharmacy they visited, or they are not really decided on which drug to take. The purchase of generic drug might be due to the fact that the prices of originator (branded drugs) were more than 30 times and the prices were ten times the international reference price in both public and private sectors (Batangan and Juban,2009).

Table 8

Brand Names of Ibuprofen, Naproxen, Celecoxib and Diclofenac Used

Brand Name of Ibuprofen	**Frequency**	**Percent**
Any brand will do	25	27.8
Alaxan	22	24.4
Advil	22	24.4
Generic	21	23.3
Brand Name of Naproxen		
Any brand will do	34	37.8
Flanax	19	21.1
Generic	37	41.1
Brand Name of Celecoxib		
Any brand will do	38	42.2
Celebrex	13	14.4
Generic	39	43.3
Brand Name of Diclofenac		
Any brand will do	26	29.9
Voltaren	25	27.8
Generic	39	43.3

1.4.4. Number of tablets/ capsules taken of NSAID per day

Table 9

Number of Tablets/Capsules per Day

Number of tablets/capsules (per day)	Frequency	Percent
1	26	28.9
2	11	12.2
3	7	7.8
Whenever I feel the pain	46	51.1
Total	**90**	**100.0**

Table 9 shows the frequency distribution of the number of tablets/capsules per day of NSAID pain reliever that respondents are taking.

As many painkillers had been available over the counter, many people just bought them without a prescription. There are 51.1% who said that they just take them during the times when they experience pain, and when got to rest or sleep, as the pain had been relieved, they do not take the drug again. There are 28.9% who took the drug once a day until the pain eased or became tolerable. But there are still those who took the drug twice (12.2%) or thrice (7.8%) a day. These people may have a short pain threshold that they need to take the drug more than once. Zelman (2020) stated that NSAID are effective to relieve pain and inflammation, it can be bought over the counter without any prescriptions.

1.4.5. Number of Days of Intake of the NSAID Pain Reliever

Table 10

Number of Days of Intake of the NSAID Pain Reliever

Number of Days of Consumption	Frequency	Percent
1 to 2	72	80.0
3 to 4	12	13.3
5 to 7	6	6.7
Total	**90**	**100.0**

Table 10 presents the frequency distribution of the number of days of intake of the NSAID pain reliever.

As many painkillers had been available over the counter, many people just bought them. Likewise, with the duration of intake of the pain reliever, there are still some people who prolonged their taking of the drug, 6.7% among the respondents lasted for 5 days until a week. But most of the respondents, 80%, last their medication up to two days. Goldstein and Cryer (2015) revealed that the most commonly used classes of medications and associated with the risk of upper GI complications can occur even with short term or linear over time continued use.

1.4.6. Duration of Intake of the NSAID Pain Reliever

Table 11 shows the frequency distribution of the respondents' use of NSAID pain relievers in terms of duration of intake. In terms of the duration of their intake of the NSAIDs, most of the respondents (63.33%) said that their intake lasted for 6 months. Some others, 26.67% lasted for more than a year and only 10% lasted for one year. The data may serve as the basis for respondents who may suffer or experience problems in their gastrointestinal tracts particularly those who take mefenamic acid. Carter (2019) claimed that mefenamic acid may increase the risk of stomach problems such as bleeding or peptic ulcers.

Table 11

Duration of intake of NSAID pain reliever

Time Frame	Frequency	Percent
6 months	57	63.33
1 year	9	10.0
More than 1 year	24	26.67
Total	**90**	**100**

1.5. Relevant Data on Non-Steroidal Anti-Inflammatory Drugs (NSAID) Pain Reliever Use

Table 12 shows the frequency distribution of the source of NSAID pain reliever information.

Table 12

Source of NSAID Pain Reliever Information

Source of Information	Frequency	Percent
Prescription	49	54.4
Pharmacist	15	16.7
Relatives	11	12.2
Advertisements	10	11.1
Friends	4	4.4
Social Media	1	1.1
Total	**90**	**100.0**

NSAIDs can be bought from pharmacies without any prescriptions. It is even available from small stores. But still many of the respondents (53.8%) bought these drugs with prescription. This may account for those respondents who seek medical advice from their physicians whenever they experience pain. Some others only ask the pharmacist which is good for pain relief as they may not have enough time to visit their doctors (17.6%). Twelve percent relied on their family members, 11% on advertisements, 4.4% on friends, and only 1.1% relied on what they have seen on social media. The findings coincide with the study of Khan (2016), which revealed that the physician responsible for the issuance of prescription to the patient were perceived as the most reliable source of NSAID information, followed by pharmacist. Similarly, physicians were perceived by patients as the most reliable source of information on knowledge of NSAID side effects and contraindications followed by media and relatives/friends (Chen, 2014 as cited by Ho, 2020)

Table 13

Source of NSAID Pain Reliever

Source of NSAID	Frequency	Percent
Pharmacy	86	95.6
Convenience store	4	4.4
Total	**90**	**100.0**

Table 13 shows the frequency distribution of the means of acquiring NSAID pain relievers. NSAIDs can be bought over the counter and they are available in all pharmacies. There are some sari-sari (convenience) stores where one could buy from. With the survey conducted, most of the respondents (95.6%) bought their anti-inflammatory drugs from the pharmacies, being aware that medicines are best bought from reliable shops. The 4.4% who bought their anti-inflammatory drugs from sari-sari stores could be that they need the drug right away and have not had enough time to go to the pharmacy. Phueanpinit (2018) argues that NSAID are widely dispensed without a prescription from pharmacist.

1.6. Respondents' Perceived Side Effects of NSAID Pain Reliever

Table 14

Perceived Side Effects of NSAIDs

Side Effect	Frequency	Percent
drowsiness/sleepiness	71	78.89
abdominal pain	22	24.44
dizziness	8	8.89
mild diarrhea	6	6.67
vomiting	2	2.22

Table 14 reveals the frequency distribution of the respondents' perceived side effects of NSAID pain relievers.

Anti-inflammatory drugs ease the pain individual experiences, but sometimes, even if they ease the pain one has, they still have undesirable side effects (MacMillan, 2015). There are a number of side effects associated with NSAIDs such as abdominal pain due to acidity, nausea, heartburn, mild diarrhea, and drowsiness/sleepiness or light-headedness particularly Ibuprofen (Barrell, 2020). There are respondents who experienced more than one side effects. The 71 out of 90 or 78.89% who may have experienced drowsiness and light-headedness might have associated it with sleepiness. But just the same, as they experience this side effect, they tend to rest and sleep. There are 22 out of 90 or 24.44% who feel abdominal pain due to acidity, dizziness is 8 out of 90

or 8.89 %, the difference in their stool is 6 out of 90 or 6.67% and vomiting is 2 out of 90 or 2.22%. These side effects usually disappear.

5. Conclusion

This study was conducted to determine the profile and patterns of intake of NSAIDs that is commonly used and available in the Philippines. Over-the-Counter NSAID is the most prescribed and widely used medicine to relive pain, reduce swelling (inflammation), and lower high temperature. The perceived side effects of NSAIDs were also identified in the study. The patterns of intake of NSAID pain relievers, the type, dosage, brand, number of tablets/ capsules taken per day, number of days and duration of intake were determined.

Based from the results, the most frequent causes of anti-inflammatory drugs intake were headache, backache, body ache, and shoulder pain which were accounted for the patients' tiredness. Many were able to seek advice from their physicians. Of which, many found out that the pains they experienced originates from respiratory related symptoms, gastrointestinal problems and hypertension.

As there are many anti-inflammatory drugs available over the counter, the most frequent drugs bought were 250 mg of generic mefenamic acid and ibuprofen of no particular brands which can be accounted for from the advice of doctors, pharmacists, relatives, or as seen in the ads. They usually took the medication for up to two days or after the pains eased. In terms of the duration on how long they take the medication, most lasted up to 6 months only, though there were respondents who lasted their intake to 1 year or longer. The brand is not an issue among respondents as most of them relied on the generics, which they normally bought from pharmacies rather than from convenience stores.

Despite the presence of perceived side-effects whenever respondents took NSAID such as drowsiness/sleepiness, abdominal pains due to acidity, dizziness and mild diarrhea, most of the respondents still manifest being dependent on the anti-inflammatory drugs seeking to relieve the pains. The use of NSAID is due to the availability, accessibility, effectivity and affordability. This is the same reason why they utilized the said drug of choice for pain and inflammation.

A similar study could be done with various groups of high-risk individuals who are taking NSAID such as those with gastritis, hypertension, and renal problems. Further, correlational study

involving the patterns of intake, side effects and the profile of the respondents could be given priority. The study among elderly who are still using NSAID could be given priority and a case study can also be considered with those NSAID users who have existing conditions such as those with cancer.

The findings from this study will serve as the basis for the development of info-drive materials and as a guide in the program implementation in order to create a well-informed NSAID users. Emphasis on the patterns of intake could be given proper attention. specifically, to those NSAID users who experienced gastrointestinal side effects on the know-how and precautionary measures.

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Learning Readiness and Level of Science Learning Outcomes in Modular Distance Modality

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Abstract

The study investigates the students' learning readiness and their level of learning outcomes in the science subject during the modular distance modality. The descriptive-correlational design gathered relevant data to determine the relationship between learning readiness and the level of learning outcomes. Through a survey questionnaire, data were gathered from 273 Grade 11 students enrolled in a public High School during the School Year 2021-2022. Based on the results, the students are moderately ready in terms of self-knowledge, analyzing context, and activating knowledge. Similarly, they are also moderately ready in terms of designing learning pathways, clarifying knowledge, and apply understanding. Likewise, the respondents are at the level of moderately engaged in their learning outcomes in Science in modular distance modality as to knowledge in terms of content, process, and nature of science knowledge, and behavior and stewardship; as to skills in terms of science inquiry and self-efficacy; as to attitude in terms of interest and motivation. Finally, a significant relationship was found between learning readiness and the level of learning outcomes in Science in modular distance modality. These results suggest that knowing how learning readiness affects the level of learning outcomes in Science in modular distance modality can help to determine, develop and enhance self-learning materials that the learners may use in the distance modality.

Keywords: *Learning Readiness, Learning Outcomes, Modular Distance Modality, Science Inquiry Skills, Self-Learning Materials*

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1. Introduction

Mastery of information with entrenched knowledge and understanding and the use of technology in a sophisticated manner are two goals of education in the 21st century. With these skills, learners are able to master the learning process, engage with their curriculum, and own and direct their learning in their individual and flexible ways. However, due to the COVID-19 pandemic, the normal operation of schools and universities has been hampered by the results of strict implementation of policies, which disrupted the attainment of the education goals. As a classic adaptive and transformative challenge, the pandemic has no pre-determined playbook that can be used to guide suitable answers. In that scenario, educators must act quickly to develop answers that are tailored to individual settings as the epidemic progresses through the educational system (Reimers et al., 2020). In the Philippines, the immediate solution was modular distance learning.

There are several studies confirming the effectiveness of the modular distance modality in education. There are contentions that it increases the student-centered approach to learning, where the learners learn in their own progress and they learn everything in the module using their own effort at their own pace even at a distant (Ambayon & Millenes, 2020). Dangle and Sumaoang (2020) assert that usage of modules encourages learners to pursue their own interests. As such, this will help them to develop superior self-study or learning skills as a result of the experience. In the same way, learners actively participate in the learning of the concepts taught in the course module as they gain a sense of responsibility as a result of completing the duties assigned to them in the module. As a result, they make significant progress on their own, as they learn and become more independent (Nardo, 2017).

As the school adopts the new normal in education with modular distance learning modality, many challenges have been encountered by the teachers and the learners. It caused them unprepared and encounter difficulties in dealing with the new normal in learning especially in the Philippines (Aucensillo, 2021). One of these challenges is the learner's readiness for learning, which questions if learners are well-equipped to learn. As this process evolves on creating favorable circumstances for the whole effective teaching-learning process, learners are expected to be ready physically, mentally, and emotionally. Being ready in all dimensions can help learners effectively learn with greater fulfillment (Dangol & Shrestha, 2019).

Without learning readiness, indications are to decrease the educational achievement of students as well as a decrease in the efficiency and effectiveness of classroom teaching. The

absence of learning readiness among learners is the reason why quality education in school becomes meaningless. Nevertheless, if the learner is ready to learn, he can learn fast while the student who is not geared up to learn, cannot learn well (Prakash, 2012). In gauging their readiness, learners are ready for learning if they are able to discern their own knowledge of a task, analyze the task's circumstances, stimulate prior knowledge relevant to the task, devise strategies for learning from the tasks, determine the need for creativity, innovation, and information on the task, and apply understanding for a better result. In the modular learning, they are ready to evaluate their own learning needs, communicate their own goals, select and use accurate ways, and examine their own learning outcomes (Heick, 2013).

In the local setting, the Malvar Senior High School, a public high school in the Philippines, conducted an online poll to get feedback on the school's chosen learning delivery method, which is Modular Distance Learning. Students were also asked on the preferred retrieval of their Self-Learning Modules (SLM) as offered by the Division office. In this setup, those who chose printed modules are provided with hard copies of SLMs to be received by their parents at designated pick-up points while students who chose non-printed modules can download copies of SLMs through Google Drive which can be accessed through Google Classroom. The provided SLMs contain self-paced learning instruction with objectives, activities, and assessments that ensure the attainment of the most essential learning competencies set by the Department of Education (DepEd). It also provided an answer key for the learners and teachers for self-check on the attainment of the needed learning competency (Repe & Student, 2021). However, the teaching of science requires more than just self-check.

As part of learning objective in science, students should demonstrate behavior and environmental stewardship as well as understanding of the nature of scientific knowledge and inquiry abilities as well as their own drive and self-efficacy. As opposed to focusing on the coverage of the subject, learning outcomes articulate how students will be able to apply the material, both within the framework of the class and in their lives in general (Phillips et al., 2018). Moreover, the advancement of science and technology has resulted to an increased amount of information available, necessitating the need for individuals to keep their knowledge up to date on a regular basis. As such, individuals not only enhance their knowledge and skills, but they continue their learning processes outside of the classroom. It is then expected that individuals with SDM will get the necessary knowledge and abilities by being aware of their learning needs (Karatas & Zeybek, 2020).

Given the local scenario, challenges and subject expectations, this study assumes that the students are considered ready in taking the science subject offered during the distance learning. This study further assumes that the students' learning readiness contributes to their achievement of learning outcomes in science. Thus, this study aims to evaluate the learning readiness and the level of learning outcomes of students in science in the modular distance modality. It answers the following hypothesis:

HO: There is no relationship between learning readiness and level of learning outcomes in science.

2. Literature review

2.1. Learning Readiness

According to Ibrahim et al. (2015) and Ridwan et al. (2019), learning readiness refers to the student's capacity to demonstrate prior knowledge and abilities in order to be successful in his/her courses and meet the demands. This prior knowledge and skills have been found to have a substantial impact on the quality of learning and student accomplishment. It can also be described as the degree of concentration and eagerness to learn among students.

The teaching and learning process without learning readiness is less effective and further becomes a serious threat to promoting educational achievement among students. Thus, the absence of learning readiness becomes a great obstacle to providing quality education (Dangol & Shrestha, 2019). Prakash (2012) describes student prepared can learn rapidly while student not geared up to learn cannot learn successfully. Every effort to provide quality education in school becomes meaningless due to the absence of student's readiness in learning. Learning readiness can increase the educational achievement of students, efficiency and effectiveness of classroom teaching.

2.1. Self-learning and Learning Readiness

Students with self-learning are able to identify their own learning needs, set their own learning goals, find the needed resources to support learning, and able to evaluate their own knowledge of the lesson. Moreover, students with high self-learning have initiative and high motivation in learning and have great curiosity, as well as a strong desire to learn. Thus, the students with high self-learning will be more active in the learning process, and have more frequent discussions or ask if they are having difficulty, not easily give up when difficulties because the students who have self-learning high takes initiative to learn and are able to find the cause of

learning difficulties, have the initiative to overcome the difficulties, and have steadiness or believe in their own abilities. It is a positive effect that increased insight and knowledge, then their study results increase (Yamin, 2011; Tekkol & Demirel, 2018; Tan & Koh, 2014, Heick, 2013; Phillips et al., 2018). This will help them to achieve the desired learning outcomes that the school and teachers want them to achieve even at a distance.

Research conducted by Purwanto (2012) showed that the higher the self-learning, the students have better the learning outcomes. Students with a high degree of self-learning are more diligent and more active during the learning process. Different from the student's medium of self-learning, they are underprivileged to monitor, evaluate, and organize their learning effectively in studying the material, but they still have awareness of learning. Thus, students who have low self-learning are lacking can get maximum results.

2.2. Module Distance Learning and Learning Readiness

Dargo and Dimas (2021) describe MDL as individualized instruction wherein teachers provide learners with the self-learning modules that will help them in giving assessment tools to check for understanding and provide immediate and appropriate feedback. In this modality, the teacher takes responsibility for monitoring the progress of the learners and learners may ask for assistance from the teacher via text messages, cell phone, or even email. In this learning delivery modality, learning takes place between the teacher and the learners who are geographically distant from each other during instruction through the use of modules (Dangle & Sumaoang, 2020).

In the Philippines, MDL modality is currently used by all public schools because it is the most preferred distance learning method of parents with children where modules can be printed and digital (Bernardo, 2020). As per the Department of Education (DepEd), it is one of the best learning modalities during a pandemic since it can help the school and the teachers provide education and the students to continue learning even when they are at home.

2.3. Students' Attitude and Learning Readiness

Attitude towards Science. Attitudes toward science are the positive or negative opinions that individuals have supported by their perceptions as a school subject, as an aspect of society, and as an individual endeavor (Osborne et al., 2003 as cited by Fulmer & Liang, 2019). Attitude could be a relatively more dispositional construct that changes slowly and influences the broad

range of perceptions, views, and values regarding science, likewise as their interest in pursuing potential careers in science.

Vedder-Weiss and Fortus (2012) found that Israeli democratic schools, which emphasize autonomy and self-direction, do not have attitude declines. Attitudes, interest, and motivation have also been found to own important peer and social support effects (Rice et al., 2013; Vedder-Weiss & Fortus, 2012), making it clear that understanding the school's academic context is important. This is in contrast with Basl (2011) based on the PISA 2006 data that showed lack of preparation on students' developing awareness of science careers. The findings of Maltese and Tai (2010) suggest that school-based activities were particularly important for students to develop an interest in science.

Self-efficacy. Self-efficacy is one of the important psychological structures that plays and important role in multiple areas of psychology. In fact, enhanced self-efficacy was found affecting the achievement of learners. It is the competence and ability to deal with life's challenges. It also refers to the extent or strength of one's belief in one's own ability to finish tasks and reach goals (Saeid & Eslaminejad, 2016). It is a motivational construct developed by Bandura in social cognitive theory referring to an individual's belief about their performance of a specific task (Tobing, 2013). Conway (2017) points out that self-efficacy addresses what people think they will do no matter what their actual skills are.

In the study of Shaker et al. (2011), study habits and academic self-efficacy were correlated with academic achievement of the students of guidance school. It was indicated that the student's academic achievement is connected to talent and effort items of academic self-efficacy variable. Thus, applying study strategies not only outcomes to improved academic self-efficacy but is also effective of the learners' academic performance that way.

Motivation. Learning motivation is the process whereby goal-directed activity is instigated and sustained. It is reflected in personal investment, cognitive, emotional, and behavioral engagement in learning activities (Geng & Niu, 2019). The motivation of accomplishment plays important role in directing the behavior of the learners. There is direct relationship between learning strategies and motivation for achievement (Farhoush & Ahmadi, 2013). Because students are not always internally motivated, they generally need situated motivation found in environmental conditions that teacher creates.

2.4. Learning Skills

Kazeni et al. (2018) defines science inquiry skills as science process skills that can acquire sets of broadly transferable abilities appropriate to many science disciplines and reflective of the behavior of scientists. According to Binti Ibrahim (2018), it is a collective of science process skills that are implemented during inquiry for the academic background in science classrooms. This skill is usually acquired by the learners in the classroom on the learning context. These skills are categorized into basic and integrated skills that eventually can develop higher-order thinking skills. Learners can acquire science inquiry skills through participation in practical investigations, which allow them to hold out activities that test hypotheses for observed phenomena. According to Brunsell (2010), helping students use evidence to create explanations for natural phenomena is central to science inquiry.

The five features of science inquiry include: learner engages in scientifically oriented questions; learner gives priority to evidence in responding to questions; learner formulates explanations from evidence; learner connects explanations to scientific knowledge, and learner communicates and justifies explanations.

3. Methodology

The descriptive-correlational design sought to gather relevant data and information to determine the relationship between the learning readiness and the level of learning outcomes of students in Science.

A survey questionnaire was utilized to obtain the data from the 273 Grade 11 students taking up Earth and Life Science subjects enrolled in a public high school in one province in the Philippines during the Academi Year 2021 - 2022. Due to their prior experiences, they can provide the necessary information required for the study. This study used the random sampling technique, a type of probability sampling in which the researcher randomly selects a subset of participants from a population. Each member of the population has an equal chance of being selected.

The instrument used in this study is a researcher-made questionnaire consists of statements that describe the learning readiness as to content (self-knowledge, analyzing context, and activating existing knowledge), process (designing learning pathways, clarifying knowledge, and applying to understand) and level of learning outcomes in science (behavior and stewardship,

interest, self-efficacy, motivation, content, process, nature of scientific knowledge, and skills of scientific inquiry). The respondents responded in reference to the Likert-type scales on the constructs covered in the study. The online survey instrument was content–validated by experts in the fields of educational management, statistics, and research. The criteria used were suitability and appropriateness of items. The final instrument was programmed in Google Form and the extracted data were analyzed using appropriate tools.

This study used mean and standard deviation to measure the learning readiness and the level of learning outcomes. On the other hand, Pearson's product-moment of correlation was used to determine the significant relationship between the variables.

4. Findings and Discussions

Table 1

Perceived Learning Readiness in Science

Indicators	Mean	SD	Verbal Interpretation
	Content		
Self-Knowledge	4.01	0.53	Moderately Ready
Analyzing Context	4.08	0.54	Moderately Ready
Activating Existing Knowledge	4.08	0.54	Moderately Ready
	Process		
Designing Learning Pathway	4.03	0.56	Moderately Ready
Clarifying Knowledge	4.03	0.58	Moderately Ready
Apply Understanding	3.96	0.55	Moderately Ready
Overall	**4.03**	**0.55**	**Moderately Ready**

Legend:4.21 – 5.00 - Very Much Ready; 3.41 – 4.20 -Moderately Ready; 2.61 – 3.40 –Ready; 1.81 – 2.60 -Slightly Ready; 1.00 – 1.80 -Not Ready.

Based on the data gathered as shown in table 1, the perceived learning readiness as to content and process of the respondents has an overall mean of 4.03 signifying that the learners are moderately ready in modular science learning. It was further revealed that the respondents assessed analyzing content and activating knowledge tied with the highest mean of 4.08 interpreted as moderately ready. Therefore, it implies that the respondents agreed to look at the context from a different perspective enhances their mastery of the content which promotes the spiral progression wherein their previous knowledge serves as a prerequisite to the present concepts supported by the

framework of the K-12 curriculum. However, the respondents assessed self-knowledge with a mean of 4.01, interpreted as moderately ready. The numbers imply that the respondents are aware that the foundational knowledge about the subject made them ready for the different concepts that may be supported by the practices of the learners as they are exposed to self-paced learning using the modules in science.

It was also found that designing learning pathways and clarifying knowledge both with a mean of 4.03, which suggests that the respondents appreciate the process in relation to their learning readiness as they see it as an opportunity to learn different concepts in Science even in the distance learning modality. They are aware of the importance of confirming the facts presented to them first before considering them true. On the other hand, apply understanding received the lowest mean of 3.96 as compared to the other two components of learning readiness to process interpreted as moderately ready. It shows that the learners can value how to process their acquired knowledge in alternative contexts most especially in real-life scenarios.

Table 2

Level of Learning Outcomes in Science in Modular Distance Modality

Indicators	Mean	SD	Verbal Interpretation
Knowledge			
Content, Process, and Nature of Science Knowledge	4.09	0.55	Moderately Engaged
Behavior and Stewardship	4.07	0.54	Moderately Engaged
Skills			
Science Inquiry	3.99	0.58	Moderately Engaged
Self-Efficacy	3.95	0.56	Moderately Engaged
Attitude			
Interest	4.06	0.58	Moderately Engaged
Motivation in Learning Science	4.15	0.58	Moderately Engaged
Overall	**4.05**	**0.57**	**Moderately Engaged**

Legend: 4.21 – 5.00 -Highly Engaged; 3.41 – 4.20 -Moderately Engaged; 2.61 – 3.40 – Engaged; 1.81 – 2.60-Slightly Engaged; 1.00 – 1.80 - Not at all

Table 2 displays the level of learning outcomes in terms of knowledge, skills, and attitude of the students with an overall mean of 4.05; learners are at the level of moderately engaged in their science lessons. The result further shows content, process, and nature of science knowledge with a mean of 4.09, interpreted as moderately engaged, which shows the core of evaluating the knowledge of the learners after they have performed tasks and activities in the subject. This signifies that students are involved in the learning and their knowledge is given importance; one cannot perform or participate without knowledge of the subject. In addition, the behavior and

stewardship was assessed with a mean of 4.07, moderately engaged. It signifies that students still recognize behavior and stewardship as part of the level of knowledge as the mean score is not drifted away from the other variable.

The level of learning outcomes in terms of skills, science inquiry with a mean of 3.99 is interpreted as moderately engaged suggesting the value of science inquiry as it may open up new knowledge and taps their potential as learners of science-related subjects. Meanwhile, self-efficacy received a mean of 3.95 as compared to the other components of level of skills interpreted as moderately engaged. This may imply that the learners reflect confidence in the ability to exert control over one's behavior, in this case, possessing participative learning skills.

The level of learning outcomes in terms of attitude, motivation in learning science attained the highest mean of 4.15, construed as moderately engaged, suggesting respondents deemed motivated to participate in science-related subjects. It benefits not only their academic performance but also their efficiency in daily tasks. The level of attitude as to interest received a mean of 4.06, interpreted as moderately engaged, connotes that the respondents still give importance to interest as it pushes them to pursue learning science-related subjects.

Having the highest mean, the respondents signifies that they are able to see the value of the attitude in learning science-related subjects. Their attitude as a learner contributes a great factor to whether they will excel or not in a particular learning area. It is a critical part that must be considered not only by the learners but the teachers of the subjects as well.

Based on the findings in table 3, learning readiness as to content in terms of self-knowledge shows a significant relationship to the level of learning outcomes in science in terms of content, process and nature of science knowledge ($r = .726$), behavior and stewardship skills ($r = .691$), skills of science inquiry ($r = .697$), self-efficacy ($r = .652$), interest ($r = .666$) and motivation ($r = .650$) when tested at $p < .01$ level of significance. Likewise, the level of learning outcomes in terms of content, process and nature of science knowledge ($r = .726$), behavior and stewardship skills ($r = .719$), skills of science inquiry ($r = .682$), self-efficacy ($r = .706$), interest ($r = .643$) and motivation ($r = .640$) aspects were significantly related to the respondent's learning readiness in analyzing the context. All variables in the level of learning outcomes in science were found to be related significantly to the respondent's learning readiness in activating knowledge. Furthermore, the respondent's learning readiness as to process in terms of designing, clarifying, and apply were significantly related to their level of learning outcomes such as content, process and nature of science knowledge ($r = .746, .643, .758$), behavior and stewardship skills ($r = .762, .690, .761$),

skills of science inquiry (r = .746, .651, .714), self-efficacy (r = .664, .623, .724), interest (r = .643, .555, .659) and motivation (r = .698, .569, .654).

Table 3

Test of Correlation between Learning Readiness and Level of Learning Outcomes

Learning Readiness	Level of Learning Outcomes					
	Knowledge		Skills		Attitude	
	Content, Process and Nature of Science Knowledge	Behavior and Stewardship Skills	Skills of Science Inquiry	Self-Efficacy	Interest	Motivation
Content						
Self-Knowledge	.726**	.691**	.697**	.652**	.666**	.650**
Analyzing Context	.726**	.719**	.682**	.706**	.643**	.640**
Activating Knowledge	.787**	.724**	.706**	.669**	.724**	.700**
Process						
Designing Pathways	.746**	.762**	.746**	.664**	.643**	.698**
Clarifying Knowledge	.643**	.690**	.651**	.623**	.555**	.569**
Apply Understanding	.758**	.761**	.714**	.724**	.659**	.654**

***Correlation is significant at the 0.01 level (2-tailed).*
**Correlation is significant at the 0.05 level (2-tailed).*
Verbal Interpretation of r-values:

+1.0 Perfect positive +/- association *+0.4 to +0.6 Moderate +/- association*
+0.8 to +1.0 Very strong +/- association *+0.2 to +0.4 Weak +/- association*
+0.6 to +0.8 Strong +/- association *0.0 to +0.2 Very weak +/- or no association*

The results of the correlation between learning readiness and level of learning outcomes show a significant relationship. The learning readiness in terms of self-knowledge, analyzing context and activating existing knowledge as well as designing learning pathways, clarifying knowledge, and apply understanding were all found to be positively correlated with their level of learning outcomes in content, process, and nature of science knowledge, behavior and stewardship skills, skills of science inquiry, self-efficacy, interest, and motivation in science. It

signifies that the learners in modular distance modality who are much ready for learning will achieve a high level of learning outcomes in science.

These findings were found to be related to the findings of Purwanto (2012) that higher self-learning in students have better learning outcomes because a high degree of self-learning activates diligence and reactiveness during the learning process. On the contrary, students with lower levels of self-learning tend to be passive because they lack the awareness to do well. With these results, the students with high self-learning are better than students with low self-learning (Kurniasih, 2010; Wijayanti & Roemintoyo, 2017).

5. Conclusion

The study sought to evaluate the learning readiness and the level of learning outcomes of science students in a modular distance modality. The descriptive-correlational design sought to gather relevant through a survey questionnaire and science inquiry skills test administered to 273 Grade 11 students. The findings have significant implications for successfully implementing the modular distance modality.

The results showed that students were moderately ready for the content in science in terms of self-knowledge, analyzing context, and activating knowledge. Similarly, they were also moderately ready to process in terms of designing learning pathways, clarifying knowledge, and apply understanding. The respondents were moderately engaged when they evaluated the level of learning outcomes in science as to knowledge in terms of content, process and nature of science knowledge, and behavior and stewardship; as to skills in terms of science inquiry and self-efficacy; as to attitude in terms of interest and motivation. The results of the correlation between learning readiness and level of learning outcomes show that there is a significant relationship. Learning readiness as to content in terms of knowledge, analyzing context, and activating existing knowledge as well as the process in terms of designing learning pathways, clarifying knowledge, and apply understanding were all found to be positively correlated with content, process, and nature of Science knowledge, behavior and stewardship skills, skills of science inquiry, self-efficacy, interest, and motivation.

Through the findings of the study, the teachers may continue to develop and enhance self-directed learning materials based on the readiness of the students as well to improve their science inquiry skills of the students.

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Scenario-Based Microlearning Strategy for Improved Basic Science Process Skills in Self-Directed Learning

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Abstract

This study determined the effectiveness of scenario-based microlearning strategy in improving the basic science process skills in self-directed learning of sixth grade students. Descriptive correlational through a pre-test – posttest and survey strategies was utilized. The pretest and posttest results measured the effectiveness of the strategy in improving the basic science process skills whereas the survey results were correlated to identify the significant relationship between the students' use of scenario-based microlearning strategy and their post-test scores. The findings indicated that respondents were very satisfied on the use of the strategy as to scenario construct and its alignment to learning style. They feel satisfied in terms of the content covered and form which revealed their very high level of planning and changing skills. The pretest and posttest showed a significant difference in all terms, except for classifying. A significant relationship was revealed between the students' use of the strategy and their posttest scores as well as the use of the strategy and level of self-directed learning skills. The findings suggest the use of scenario-based microlearning strategy as an alternative approach in teaching science to improve the basic science process skills and self-directed learning skills of learners.

Keywords: *scenario-based microlearning strategy, basic science process skills, self-directed learning, perceived experience*

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1. Introduction

The science education aims to develop scientific literacy among students. As such, the curriculum envisions the development of scientifically, technologically, and environmentally literate and productive members of society who manifest skills as a critical-problem solver, responsible stewards of nature, innovative and creative citizens, informed decision makers, and effective communicators. With the demanding nature of subject objectives, content and processes are interrelated; without science content, learners will have difficulty in developing science process skills. Development of science process skills among elementary learners is significant because it the foundation of learning more complex skills. This means that developing these student's skills enable them to understand the knowledge or concepts, independently discover and acquire necessary facts, concepts, and values.

According to Karamustafaoglu (2011) as cited by Supriyatman and Sukarno (2013), science process skills (SPS) includes observing, asking questions, classifying, measuring, and predicting while NARST.org refers to observing, inferring, measuring, communicating, classifying and predicting. Ostlund (1992) as cited by Ergül et al. (2011) affirms that SPS are the building-blocks of critical thinking and inquiry in science. Unfortunately, learners showed low performance in the national and international science subject assessments. Results also show that among the subjects being taught in the class, science is one of the subjects gaining low Mean Percentage Score (MPS) along with English and Mathematics. According to SEI-DOST & UP NISMED (2011), the reasons affecting students' performance include the quality of teachers, the teaching-learning process, the school curriculum, instructional materials, and administrative support.

With various learning modalities during pandemic, Self-Learning Modules (SLMs) are the primary learning resources for the learners aside from textbooks and other printed materials. However, some learning modules and textbooks fail to arouse students interest because of large masses of data or content information. They find it difficult to absorb large amount of information being presented in the SLMs and textbooks. Likewise, they may not see the relevance of the topics to their personal lives because some activities were not contextualized. Learning Modules given to the learners are self-directed, this means that leaners also need to have the skills for learning aside from the skills that they need to perform in science lessons. In self-directed learning, individuals must know how to take charge of their learning including the processes of planning, developing, adapting and changing (Brandt, 2020). This is the process where individuals take time

to plan, continue and evaluate their learning experiences (Merriam & Baumgarther, 2020). However, students are disadvantaged with some distractions at their home learning environment.

Given the challenges and difficulties in learning science in the new normal of education, instructional materials, teacher's methodology, integration of technology and learner's skill development, this study assessed the researcher's implementation of the student-centric scenario-based microlearning strategy in science to see its effectiveness and its relationship to the learners' basic science process skills and self-directed learning skills.

2. Literature review

2.1 Scenario-Based Microlearning

Scenario-Based Learning (SBL) is a useful method for active learning like case-based education and uses a realistic setting in which challenges are given in a certain order and options are available to help the learner achieve a goal (Tupe, 2015). As a method of life-like scenarios, it uses digital media to give context to training content and make the topics more relatable (Galhotra, 2020). It is also a method to organize instructional materials with chunked scenarios that learners are efficiently able to learn (University of Wisconsin, 2015). The framework starts with informing a scenario by providing text and images followed by decision making through multiple choice and the like and reviewing decisions made by providing additional instruction.

SBL is a great instructional strategy in an online training as it utilizes active learning approach where real-life scenarios offer relatable learning experiences (Jagga, 2021). According to Sengupta (2019), it works in developing hard skills which involve the cognitive part of the brain because it creates emotional and behavioral connection with the learner. In addition, learners develop soft skills in making choices and relating them to the situation. It also promotes situational awareness because students can learn making correct decision based on the given scenario. This strategy creates authentic experience and learning in a safe training environment that learners can apply what they learned with confidence (Sheldon, 2020).

A microlearning approach is necessary to make SBL more effective. This extra is the broad range of scenarios or situations that train people skills and situational awareness. A content-rich story engages emotion and learners feel the relatedness to the topic. Storytelling scenarios when implemented with static picture, text, animated or live videos can be interactive for learners (Maddox, 2018).

2.2 Basic Science Process Skills and Self-Directed Learning

Science process skills involve means and methods to reach scientific information that allow pupils to think scientifically (Yumusak, 2016). The theory, principles, and laws are part of science content which are included in scientific knowledge (Erturk et al., 2010). It refers to the basic skills of facilitating learning, allowing learners to be engaged and participative, developing autonomy, retention of learning and providing solution to a problem through research. Science process skills are divided into two groups: basic and integrated process skills. The basic process skills include observing, asking questions, classifying, measuring and predicting while integrated process skills include identifying and defining variables, interpreting data, manipulating materials, recording data, formulating hypotheses, designing investigations, making inferences and generalizations (Karamustafaoglu, 2011). When an individual learned these things, they are learning scientific knowledge through science process skills. The science process is beneficial not only in science, but in every scenario that necessitates critical thought. Observing traits, measuring quantities, sorting/classifying, inferring, forecasting, testing, and communicating are examples of science process abilities (Vitti and Torres, 2016).

Self-Directed Learning (SDL) is a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes (Kamilali & Sofianopoulou, 2013). As cited by Brandt (2020), SDL includes five processes: one's initiative in identifying his needs, identifying their goals, determining resources needed, ability to discern, and assessing and evaluating learning outcomes. In SDL, the responsibility to learn shifts from an external source (teacher, etc.) to the individual. Control and active involvement of the learner in the learning process is crucial in this process. It includes the conceptualization, design, implementation and evaluation of learning guided by learners (Brookfield, 2009) and may be referred to as a method of organizing learning which learners control the task of learning. In order to achieve learning objectives, individuals take responsibility for their own learning and embrace individual autonomy and preferences (Kaufman, 2003).

2.3 Theoretical Framework

The theory of situated learning, cognitive load, and information processing served as the bases for the conceptualization of the study.

Situated learning theory argues that learning best happens in the context of the experience. It gives great emphasis on building understanding through relating and interacting with others. Situated learning provides learners the chance to be engaged with real-life events, problems, and tasks in a context. Students learn better when presented with realistic problems which they need to think through and act on it (Kurt, 2021). As such, this theory illuminates the elements of scenario-based microlearning strategy where learners are offered with contextualized scenarios related to experiences.

Cognitive Load Theory suggests that learning happens best under conditions that are aligned with human cognitive architecture. It is concerned with techniques for reducing working memory load in order to facilitate the changes in long term memory associated with schema acquisition (Solomon, 2018). The theory of cognitive load can be best applied in the areas where learning concepts are complex or challenging competencies. It is evident that people will have difficulty in learning broad lessons and dividing the learning task little by little from broader to specific would help the learners achieved learning goals.

Information Processing Theory by George Miller has two theoretical ideas. One concept is “chunking” and the capacity of short term memory. A chunk could refer to digits, words, chess positions, or people’s faces. The concept of chunking and the limited capacity of short term memory became a basic element of all subsequent theories of memory. An example of chunks is the ability to remember long sequences of binary numbers because they can be coded into decimal from, this way the chunks are meaningful.

3. Methodology

The study employed descriptive correlational and pre-test –posttest design for mustering necessary information and data. A correlational research design investigates relationship between variables without the researcher manipulating any of them (Bhandari, 2022). On the other hand, in descriptive comparative design, the researcher manipulated an independent variable and measure its effect on a dependent variable. It was utilized since the study aimed to determine the effectiveness and relationship of scenario-based microlearning strategy in improving the respondents’ basic science process skills and self-directed learning.

The respondents of the study were the group of Grade six pupils enrolled in one public elementary school in the Division of Quezon Province in the Philippines during the academic year 2021-2022. The group has 40 students under the teaching supervision of the researcher as Science 6 teacher. The grade six pupils were chosen as the respondents of the study as they experienced distance learning and has been using Self-Learning Modules since academic year 2020.

The researcher-made pretest and posttest exam, composed of 50 item multiple-choice questions based on the competencies in the third grading quarter of Science 6, assessed the respondents' basic science process skills before and after the implementation of the strategy in terms of observing, inferring, communicating, classifying, and predicting. A researcher-made survey questionnaire on the perceived experience of the respondents on the use of the strategy was administered after the implementation. It was based from the elements of scenario-based microlearning in terms of scenario-construct, content covered, alignment to learning style and form. Another researcher-made survey questionnaire on the assessment of the level of self-directed learning skills was also given after the exposure to the strategy. Specifically, there were five statements in each self-directed learning skill namely: planning, developing, adapting, and changing. Both survey questionnaires used a four point Likert-scale where the respondents may agree or disagree. These survey questionnaires were validated by a supervisor, a school head, two master teachers, and a language expert and it went through pilot testing and reliability test. The reliability test performed on the assessment of the level of self-directed learning skills of the respondents revealed that self-directed learning skills in terms of planning had internal consistency of 0.715 interpreted as "acceptable" and while developing, adapting, and changing had internal consistency of 0.824, 0.873, and 0.803 respectively and interpreted as "good".

Lesson exemplars utilized in this study was based from the scenario-based microlearning strategy. It followed the design format prescribed by the Department of Education based on PIVOT I-D-E-A (Introduction, Development, Engagement, and Assimilation) Lesson Exemplar. It included the Most Essential Learning competencies (MELC) in the third grading period of Science 6. Moreover, the lesson material aligned to the lesson exemplar was entitled Scenario-Based Microlearning Lessons in Science 6. It was developed by the researcher based on the Most Essential Learning Competencies (MELCs) in the third grading period of Science 6. Similar to the lesson exemplar, it followed the lesson format prescribed by the Department of Education for lessons materials based on PIVOT I-D-E-A (Introduction, Development, Engagement, and

Assimilation) lessons. The materials were checked and validated by a district content evaluator, language evaluator, and technical evaluator.

The gathered data obtained were analyzed by utilizing both descriptive and inferential statistics. Mean and standard deviation were used to describe the responses of the learners in terms of perceived experience on the use of scenario-based microlearning strategy and the level of self-directed learning skills. Frequency count and percent distribution determined the number and portion of respondents in different performance level in terms of basic science process skills test. In determining the significant difference between the mean pre-test and mean posttest scores of the respondents, paired t-test was utilized. Pearson Product-Moment Correlation were used to calculate the significant relationship.

4. Findings and Discussion

Table 1 shows the result of the survey on the perceived experience of the respondents on the use of scenario-based microlearning strategy in terms of four categories namely; scenario-construct, content covered, alignment to learning style and form. Each category is composed of five indicators where the respondents provided their level of agreement and satisfaction.

In terms of the perceived experience as to scenario construct, the overall mean of 3.525 reveals that the respondents strongly agree towards the statements. This means that the respondents are very satisfied with how the scenarios are constructed in the lessons. The students perceived that scenarios used in the lessons are relatable, reflective, motivating, engaging, and help them solve problems or activities. These are similar to Jagga (2021) that SBL is a great instructional strategy in online training because it utilizes active learning approach where real-life scenarios offer relatable learning experiences.

As to the perceived experience on how the content is covered in the lesson, the overall mean of 3.465 reveals that the respondents agree towards statements. This implies that the respondents are satisfied with how the contents are covered in each lesson. Since the topics in the lessons were chunked and sub-tasked, the learners were able to focus on understanding and accomplishing the tasks. Relative to the suggestion of BenchPerp (2021), effective teaching through microlearning requires implementers to consider the theory of cognitive load where repeated or unnecessary information can be removed to reduce the cognitive load.

Table 1

Perceived Experience on the Use of Scenario-Based Microlearning Strategy

Statement	Mean	SD	VI
Scenario Construct			
1. The scenarios in the lessons are relatable to my experiences.	3.20	.516	A
2. The scenarios presented in the lessons help me reflect on my learning.	3.88	.335	SA
3. The scenarios in the lessons offers real-life experiences.	3.50	.555	A
4. The lessons provided engaging and motivating tasks and activities through the scenarios.	3.33	.526	A
5. The scenarios of the lessons make it easy to solve problems and activities.	3.72	.452	SA
Overall	**3.525**	**.1794**	**SA**
Content Covered			
1. The content of every lesson is short but meaningful.	3.57	.675	SA
2. The contents of the lessons are suitable to my learning needs.	3.58	.549	SA
3. The objectives of the lessons are achievable for me.	3.38	.586	A
4. Short span of time is needed to accomplish each tasks in the lesson.	3.05	.677	A
5. The content of the lessons help me do the tasks.	3.75	.439	SA
Overall	**3.465**	**.2914**	**A**
Alignment to Learning Style			
1. The Illustrations of scenarios helped me understand the lessons.	3.73	.452	SA
2. The scenarios of the lessons make it interesting to read.	3.62	.490	SA
3. The scenario-based tasks offer hands-on activities.	3.50	.555	A
4. The lessons provided opportunities to demonstrate my skills.	3.60	.591	SA
5. The materials used for learning were suited to how I usually learn.	3.43	.636	A
Overall	**3.575**	**.2835**	**SA**
Form			
1. The scenarios in the lessons is presented in series form which is effective.	3.63	.490	SA
2. The form of the material is appropriate to my needs as a learner.	3.55	.639	SA
3. The material format is flexible and can be viewed using other devices.	3.12	.686	A
4. The text and illustrations of the materials are simple and recognizable for me.	3.53	.599	SA
5. The design and layout of the materials are attractive and pleasing to me.	3.55	.552	SA
Overall	**3.475**	**.3061**	**A**

Legend: 3.51- 4.00- Strongly Agree (Very Satisfied); 2.51-3.50-Agree (Satisfied); 1.51- 2.50- Disagree (unsatisfied); 1.00- 1.50-Strongly Disagree (Very Unsatisfied)

Moreover, the overall mean of alignment to learning style which is 3.575 reveals that the respondents strongly agree on the statements. This means that the learners are very satisfied on how the lessons are aligned to their method of learning which address their needs and the way they enjoy learning as lesson materials presented stories in the scenarios. Similar to the description of Maddox (2018), content-rich story engages emotion and learners feel the relatedness to the topic. Storytelling scenarios when implemented with static picture, text, animated or live videos can be interactive for learners.

Lastly, the respondents agree towards the statements pertaining to the form of scenario-based microlearning strategy as the overall mean shows 3.475. This explains that they are satisfied on how the materials of the lessons are presented which help them understand the lessons. The materials given to learners were in two forms, digital and printed. Learners who have gadgets at home were able to view the material digitally and each learner was also provided with a printed copy. It is inclined to the claim of Ghasia and Rutalola (2021) where microlearning methods can be complemented with other modalities and modules can be reformatted with microlearning characteristics and be delivered to the learners.

Table 2

Pre-test and Posttest Result on the Basic Science Process Skills Test

PRE TEST SCORES										
Level	**OBS**		**INF**		**COM**		**CLAS**		**PRED**	
	Ƒ	**%**	**Ƒ**	**%**	**Ƒ**	**%**	**Ƒ**	**%**	**Ƒ**	**%**
Beginning	7	17.5	5	12.5	21	52.5	6	15.0	13	32.5
Developing	23	57.5	12	30.0	12	30.0	16	40.0	14	35.0
Approaching Proficiency	7	17.5	18	45.0	6	15.0	9	22.5	11	27.5
Proficient	3	7.5	5	12.5	1	2.5	6	15.0	2	5.0
Advanced							3	7.5		
TOTAL	40	100	40	100	40	100	40	100	40	100
POSTTEST SCORES										
Level	**OBS**		**INF**		**COM**		**CLAS**		**PRED**	
	Ƒ	**%**	**Ƒ**	**%**	**Ƒ**	**%**	***f***	**%**	**Ƒ**	**%**
Beginning	1	2.5	0	0	12	30.0	5	12.5	0	0
Developing	9	22.5	6	15.0	12	30.0	11	27.5	10	25.0
Approaching Proficiency	16	40.0	12	30.0	10	25.0	14	35.0	13	32.5
Proficient	12	30.0	15	37.5	5	12.5	8	20.0	14	35.0
Advanced	2	5.0	7	17.5	1	2.5	2	5.0	3	7.5
TOTAL	40	100	40	100	40	100	40	100	40	100

Legend: OBS - Observing; INF – Inferring; COM – Communicating; CLAS – Classifying; PRED – Predicting

Table 2 shows the scores of the respondents on the pre-test and posttest in the basic science process skills test in terms of observing, inferring, communicating, classifying, and predicting. The pre-test scores reveal that most of the respondents are in the developing level. After the implementation of the strategy, the posttest scores show that most of the respondents fall under approaching proficiency level and proficient level.

Under observing skill, the learners are required to use their senses in order to gather information about an object or event. The pre-test scores show that the biggest percentage (57%) of the respondents are in the developing level during the pre-test exam while the posttest result indicates that the performance of the respondents has improved as the largest percentage (40%) of them are in the approaching proficiency level. This implies that the activities provided in the lesson of gravity, friction, and energy require learners to perform experiments to observe and analyze the result of their outputs.

It can be gleaned from the pre-test scores under inferring skill, where learners need to make an educated guess about an object or events, the biggest percentage of the respondents are in the approaching proficiency level (45%). The posttest results reveal better performance as the largest percentage (37%) of the respondents fall under proficient level. Hence, the learners' prior knowledge and new experiences on the utilization of lesson material contribute to their better performance in making educated guess to answer the situational assessments.

On the other hand, communicating skill shows that the 30% of the respondents are in the beginning level and developing level, but the percentage of beginning level from the pre-test (52.5%) has decreased. It also reveals improvement as the number of learners move to a higher level of performance because of the increase in percentage on other approaching proficiency up to advanced level.

Moreover, under classifying skill, where learners are expected to group or order objects or events based on the criteria, the biggest percentage of the learners (40%) fall under developing level. It is notable that even in the pre-test exam, 15% of the respondents are in the proficient level, and 7.5% are in the advanced level. In the posttest, the results reveal the biggest percentage of the respondents are in the approaching proficiency level (35%). The learners were able to practice their classifying skill, specifically in the lessons of simple machines where the activities focused on classification. Through this, learners were able to group objects or things according to its function, criteria or characteristics.

The table further reveals in predicting skill, the respondents show better performance in the post-test under predicting skill where most of them are at the proficient level (35%), compared to the result of pre-test where most of the learners are in developing level (35%). Since leaners were exposed to task-scenario-based tasks, it greatly influenced how they anticipate the future based on the pattern of evidence. The topic about the safety precautions on handling simple

machines provides way to practice learners' predicting skill as they experience the activity and determine what would happen to a certain scenario or situation.

The implication of the results is similar to what the literature claims that using scenario in lesson can contribute positively in the pupils' learning. For instance, Tupe (2015) found SBL a useful method for active learning that gives a good foundation. SBL, like case-based education, uses a realistic setting in which challenges are given in a certain order and options are available to help the learner achieve a goal.

Table 3

Level of Self-Directed Learning Skills after Exposure to Scenario-Based Microlearning Strategy

Statement		Mean	SD	VI
	Planning			
1.	I identify my strengths and weaknesses in learning.	3.43	.594	A
2.	I make my own schedule while learning.	3.18	.636	A
3.	I set my objectives or goals when learning.	3.60	.496	SA
4.	I prepare the things I need before studying.	3.88	.404	SA
5.	I make sure to have a good space for learning.	3.68	.474	SA
	Overall	3.550	.2855	**SA**
	Developing			
1.	I make sure to follow the schedule I set for learning.	3.48	.679	A
2.	I apply/practice what I learned in the lessons.	3.68	.474	SA
3.	I review the lesson again if I do not get it the first time.	3.43	.549	A
4.	I use different way of learning, like using gadgets and other learning resources.	3.05	.639	A
5.	I use my prior knowledge to understand the new lesson.	3.65	.483	SA
	Overall	3.455	.2717	**A**
	Adapting			
1.	I am willing to collaborate and share my knowledge.	3.12	.686	A
2.	I treat mistake/failure as a learning opportunity.	3.40	.545	A
3.	I stay focused and determined in learning even at critical or difficult times.	3.43	.549	A
4.	I am eager to learn new skills or to try new things.	3.65	.580	SA
5.	I am open to feedback about my learning progress.	3.33	.474	A
	Overall	3.385	.2949	**A**
	Changing			
1.	I am open to changes when it comes to my learning.	3.75	.439	SA
2.	I am open to new ideas when learning.	3.45	.597	A
3.	I am willing to change my ideas for better way of learning.	3.55	.552	SA
4.	I willingly accept advice from others when it comes to my learning.	3.80	.405	SA
5.	I ask assistance when there is a problem I cannot resolve.	3.28	.599	A
	Overall	3.565	.2517	**SA**

Legend: 3.51- 4.00- Strongly Agree (Very High); 2.51-3.50-Agree (High); 1.51- 2.50- Disagree (Low); 1.00-1.50-Strongly Disagree (Very Low)

Table 3 shows the result of the survey for the level of self-directed learning skills of the respondents after being exposed to scenario-based microlearning strategy in terms of four categories namely; planning, developing, adapting, and changing. Each category is composed of five indicators where the respondents provided their level of agreement.

In terms of self-directed learning skills as to planning, the overall mean of 3.550 reveals that the respondents strongly agree towards the statements. This indicates that the respondents have very high level of planning skills. The respondents tend to plan their own learning considering different factors such as time, resources and environment corresponding to the description of Kaufman (2003). It is viewed target that learners strive to achieve by taking responsibility for their own learning and embracing individual autonomy and preferences.

As to the developing skill, the overall mean of 3.455 reveals that the respondents agree to the statements. This means that they have a high level of interest in learning which is being developed through the application of prior knowledge and utilization of available learning resources. Similar to the description of Leong (2020), curiosity builds interest on the part of the learners and through the process of self-directed or self-regulated activity, learners can develop a more advanced forms of cognition.

Furthermore, the overall mean of adapting skill which is 3.385 discloses that the respondents agree on the statements. This indicates that they have high adapting capability when it comes to self-directed learning. The respondents show that they are able to adapt into different situation towards their own growth and learning. Similar to the findings of Sheldon (2020), exposure to scenario-based learning is beneficial to learners. It creates authentic experience, students learn in a safe training environment and learners can apply what they learned with confidence.

Lastly, the respondents strongly agree towards the statements pertaining to changing skill as the overall mean shows 3.565. The results indicate that the respondents have a very high level of response to changes while learning and they are open to changes. This implies that respondents have a positive response on the implementation of a new strategy in learning science which is the scenario-based microlearning strategy. The learners are able to reflect on their strengths and weaknesses and assess their skills and abilities. This was visible from the reflection made by the learners as part of the tasks in each lesson where the learners have to identify the part of the lesson

which they enjoy and find themselves struggling. It supports the self-directed learning processes provided by Malcolm Knowles cited by Brandt (2020) which includes the process of assessing and evaluating learning outcomes.

Table 4

Test of Difference in the Pre-test and Posttest Scores

Basic Science Process Skills	Mean Diff.	SD	Paired Differences			T	df	Sig. (2-tailed)
			Std. Error Mean	95% CID Lower	95% CID Upper			
Observing	2.150	1.819	.288	-2.732	-1.568	7.474	39	.000
Inferring	2.700	2.090	.331	-3.369	-2.031	8.169	39	.000
Communicating	.750	1.565	.247	-1.250	-.250	3.031	39	.004
Classifying	.125	2.015	.319	-.769	.519	.392	39	.697
Predicting	2.550	1.921	.304	-3.164	-1.936	8.396	39	.000

Table 4 presents the significant difference in the scores of the respondents before and after being exposed to scenario-based microlearning strategy. The obtained data reveal that there is a significant difference in the scores of the respondents at 0.05 level of significance among all the skills, except for classifying. The results indicate that there is notable improvement on these skills of the respondents in basic science process skills test.

The scenario-based microlearning strategy used in the lessons and in the tasks help learners to improve their basic science process skills in terms of *observing.* Most of the tasks in the materials require learners to observe the environment and experience the real scenario at home. It also explains the theory of situated learning which provides learners the chance to be engaged with real-life events, problems, and tasks in a context.

Additionally, the scenario-based microlearning strategy enable learners to increase their scores in terms of inferring skill. Every after the scenario-based activity of the lesson, inferential questions were provided to guide the learners in accomplishing the tasks. As the findings of Dewitz (2017) showed that when learners are exposed to inferential questions, they will read more deeply and engage in inferential thinking.

Furthermore, there is a significant difference in terms of communicating which means that the strategy is effective in improving their skill. The lesson materials offer engaging images and

illustrations which guide learners in expressing their idea through words or conveying their thoughts through graphics. This supports Garner (2017) that illustration is a way of communication through images that helps create interest and captures people's attention spans.

On the other hand, it can be gleaned that there is no significant difference in the scores of the respondents in terms of *classifying skill*. The result indicates that the lesson materials given to the learners requires more activities in order to improve their classifying skill. Ramesh (2017) suggested that teachers need to adopt constructive method of teaching wherein materials, substances and etc. is being given to students for classification.

Lastly, the data obtained show that there is a significant difference in terms of predicting skill. Therefore, the exposure to various scenarios in the lessons enable learners to predict an outcome based from the situations or instances. Barman et al. (2008) stated that prediction is based from the result of previous experiences. He gave emphasis on the importance of past observation regarding a particular event in the reliability of a prediction.

Table 5

Test of Relationship Between the Perceived Experience on the Use of Scenario-Based Microlearning Strategy and the Post-test Scores in Basic Science Process Skills Test

Scenario-Based Microlearning	**Science Process Skills**				
	Observing	Inferring	Communicating	Classifying	Predicting
Scenario Construct	-.067	0.19	-.151	-.037	.247*
Content Covered	-.007	-.027	.118	-.198	.109
Alignment to Learning Style	-.067	.205*	-.027	-.053	.122
Form	-.071	0.77	-.047	-.010	.330*

***Correlation is significant at the 0.01 level (2-tailed)*
**Correlation is significant at the 0.05 level (2-tailed)*

The table 5 presents the relationship between the perceived experience of the respondents on the use of scenario-based microlearning strategy as to scenario construct, content covered, alignment to learning style, and form with post-test scores of the respondents on basic science process skills in terms of observing, inferring, communicating, classifying, and predicting.

The obtained data reveal that there is a significant relationship between the scenario-construct and predicting skill. This indicates that the how the scenarios are constructed in the lesson material help learners to identify a possible outcome for a future event based on the pattern of

evidence. Cote (2021) emphasized that analysis of data is significant to forecast potential scenarios which can help produce strategic decisions.

The table also shows that alignment to learning style has significant relationship with inferring skill. The lesson materials offer various comic-style scenarios about the topics, learners tend to enjoy learning as they read the stories. Boris (2019) cited that a well-told story can be remembered more accurately and longer than learning with just facts and figures.

Finally, it can be gleaned that form is significantly related to predicting skill. This indicates that how the lesson materials are presented to the learners help them forecast a future event based on evidence. Gaither (2011) stated that in order to successfully make predictions about informational text, teachers should make sure to include time for instruction, modelling, and practice.

Table 6

Test of Relationship Between the Perceived Experience on the Use of Scenario-Based Microlearning Strategy and the Self-Directed Learning Skills

Scenario-Based Microlearning	**Self-directed Learning**			
	Planning	Developing	Adapting	Changing
Scenario Construct	.466**	-	.463**	.440**
Content Covered	.348*	-	.358*	-
Alignment to Learning Style	-	-	.363*	-
Form	.337*	.405**	.479**	.328*

***Correlation is significant at the 0.01 level (2-tailed).*
**Correlation is significant at the 0.05 level (2-tailed).*

Table 6 shows the relationship between the perceived experience of the respondents on the use of scenario-based microlearning strategy as to scenario construct, content covered, alignment to learning style, and form with their self-directed learning skills in terms of planning, developing, adapting, and changing.

The obtained data reveal that scenario construct has significant relationship with planning, adapting, and changing skill. This means that the learners were able to improve their planning skill by considering how the scenarios are constructed in the lesson materials. Moreover, the scenarios presented in the lessons help learners to adapt and change because every lesson offers opportunity for learners to reflect on their own learning where they need to identify what they learn and how they feel about a particular lesson. Cavilla (2017) emphasized that reflection as a tool for learning

has the transformative ability to change the way the students think and adapt their effort, motivation, and ability to accomplish certain tasks.

The table also shows that the content covered is significantly related to planning and adapting skill. The lesson materials for the strategy considered the element of microlearning which offers well-planned chunked lessons and bite-size activities. It helped learners to plan their learning by allotting shorter time to accomplish the tasks in the lessons. Patel (2022) suggests planning to produce quality outputs consider the time spent to achieve goals.

Moreover, the table reveals that alignment to learning style has significant relationship with adapting skill. The learners were able to align and adapt their style of learning as to what is needed to be demonstrated or performed based on the activities. Similar to Sengupta (2019), scenario-based microlearning does not only improves hard skills, but it also works for soft skills such as adapting skill where learners are able to make choices along the way and they are to relate to the different situations.

Lastly, the form of scenario-based microlearning strategy is significantly related to all of the skills in self-directed learning. The flexibility of the lesson materials help learners adapt and change based on their accessibility to gadgets and other forms of learning. Relevant to Kadhem (2017), the quality of course's design in terms of delivering the required information and activities is critical to its success.

5. Conclusion

The primary aim of this study was to determine the effectiveness and relationship of scenario-based microlearning strategy in improving the basic science process skills and self-directed learning Grade 6 pupils. Additionally, it examined any significance difference in the pre-test and posttest scores of the respondents in the basic science process skills test. It further examined any significant relationship between the perceived experience of the respondents on the use of the strategy and their posttest scores in the test and in their level of self-directed learning skills.

The results revealed that the learners feel very satisfied in terms of their experience in the use of scenario-based microlearning strategy as to scenario construct and its alignment to learning style and feel satisfied in terms of content covered and its form. The performance of the

respondents in the basic science process skills test showed better scores in the posttest result as most of the learners fall under proficient level in inferring and predicting skill; approaching proficiency in terms of observing and classifying skill; and developing level under communicating skill. It further revealed that a very high level of planning and changing skill were shown by the respondents and a high level of developing and adapting skill were demonstrated. Significant difference was found in the pre-test and posttest scores of the respondents in all of the basic science process skills, except for classifying skills. The test of relationship disclosed significant relationship between the perceived experience of the respondents on the use of the strategy and their posttest scores. Likewise, significant relationship was shown between the perceived experience of the learners on use of the strategy and their level of self-directed learning skills.

This study suggests that teachers may use scenario-based microlearning strategy as an alternative approach in teaching science lessons to make topics more engaging and relatable. Teachers are also encouraged to provide activities which can further enhance basic science process skills of learners. It is also recommended that further studies may to be conducted regarding the same area of concentration or with different variables to see more comprehensive findings. This may improve Science education and benefit more learners.

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Problem-Based Learning Materials in Upskilling Mathematics Critical Thinking Skills

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Abstract

This study aimed to determine the effectiveness of Problem-Based Learning (PBL) material to the critical thinking skills of Grade 10 students in Mathematics. The study used experimental research design by measuring the improvement on the performance of the students after the implementation of the researcher-made PBL material. It also used survey strategy to assess the acceptance of the students on the quality of the developed PBL material and correlated the results with the critical thinking skills before and after the use of the material using paper and pen test. Results revealed that learning experiences relate to inferring, communicating, and problem-solving. There is also significant relationship between learning outcomes and communicating and problem solving. Both effectiveness and efficiency and user-friendliness significantly relate to communicating learning experience while congruence relates significantly to all critical thinking skills. Thus, learners' use of the PBL material increases their critical thinking skills as evidenced by the t–test results showing significantly different critical thinking skills before and after the use of PBL material. With the improved level of students' critical thinking skills, the PBL material may be used as a supplementary in the delivery of the lessons in any subject area.

Keywords: *Problem-Based Learning,, Critical Thinking Skills, Mathematics, Learning Materials*

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1. Introduction

Improving learners' critical thinking skills is the primary focus of educators, especially in teaching mathematics. Learning mathematics is closely related to the practices and methods of learning and thinking since the characteristics of mathematics are mathematics and human activity, that is, mathematics is a method of thinking, a method of organizing logical evidence, which is carefully used by defined terms, clear, and accurate (Mendoza, 2018).

The common problem among students today is understanding a mathematical concept only in its theoretical context with critical thinking skills underdeveloped. For example, in the most recent profile of non-numerates in San Bartolome Integrated High School (SBIHS), at least 38.52% of Grade 7 students for the school year 2019 – 2020 are considered non-numerates. From this context, non-numerates were assessed as those who got a score below 9 out of a 40-item teacher–made and expert–validated standardized test for numeracy. This statistic is further supported by the results of the First Quarterly Mean Percentage Score (MPS) with the Mathematics MPS being second to the lowest in 8 of the subjects, with almost all numbers leading to a decline in the Mathematics Performance of the Learners (SBIHS School Monitoring, Evaluation and Adjustments, 2020).

Problem-based learning (PBL) can naturally shape student thinking activities and help them solve their learning problems (Rosy & Pahlevi, 2015). PBL is also more effective than conventional classroom instruction and has a positive impact on student critical thinking skills (Asyhar, 2015). As PBL can help to build new knowledge (Padmavathy & Mareesh, 2013), critical thinking skills in mathematics must be continually developed, particularly through PBL.

In this study, the PBL material applied three approaches: individual investigations, collaborative investigations or presenting assignments. As such, this study aimed to determine the effectiveness of PBL material in improving critical thinking skills of Grade 10 students in Mathematics. Specifically, it aimed to evaluate the PBL material based on learning experiences, learning outcomes, effectiveness and efficiency, user-friendliness, and congruence. During the implementation, it assessed the level of critical thinking skills of the students before and after the use of the material in terms of observing, analyzing, inferring, communicating, and problem-solving. For the statistical inference, the study revealed that there is significant difference in the pretest and posttest level of critical thinking skills of the student-respondents.

2. Literature review

2.1 Problem-Based Learning (PBL)

Problem-based learning approaches improve students' abilities to adapt or transfer their thoughts to new situations and tasks. They achieve this through cultivating greater awareness of the subject: they consider the assignments and settings of various learning situations, as well as themselves as students in these contexts. Pintrich (2012) observes that students must "think about" these systems rather than merely practicing them. As Zohar and Barzilai (2015) point out, knowledge development is required as one learns.

Hitchock (2014) used the term "problem-based learning" to describe the process of pondering reasoning. With PBL, students become more aware of own learning experiences and the exercises include into personal and professional development. They are more prepared to comprehend themselves throughout the learning process and can develop ability to contemplate, interact with, and evaluate learning on a daily basis. PBL can help students tackle their learning challenges by naturally shaping their thinking activities (Baharun & Ummah, 2018). It is also more successful than regular classroom instruction and improves students' critical thinking abilities (Asyhar, 2015). Critical thinking skills in mathematics must be regularly strengthened, notably through PBL, because PBL can assist build new knowledge (Padmavathy & Mareesh, 2013).

2.2 PBL Materials

Learning resources are good technique to bridge the gap between the learners' requirements and the knowledge and skills they need to learn. Understanding the soft-skills pupils must possess is critical to implementing PBL. When it comes to problem-based learning, the capacity to communicate, think critically, compromise, and collaborate are all necessary skills. The teacher must be aware and need to devote time to teaching and assessing these abilities. Students must also be able to evaluate themselves and their peers, as well as express what they have learned and justify their solutions. Furthermore, the instructor must anticipate when pupils may become stuck and what materials they will want (Kuhfeld et al., 2020).

Individual lessons, units, and even entire curricula can be taught using PBL. It is frequently used in a team setting to develop skills such as consensus decision making, communication and discussion, team maintenance, conflict resolution, and team leadership. While the core method of

problem solving in placed environments has been employed throughout the history of education, the term PBL was not coined until the 1970s as an alternative to medical education (Jones, 2013).

2.3 Critical Thinking Skills

Thinking is a cognitive process for gaining knowledge. The ability to think is a skill that can be learned. The three crucial parts of thinking skills are critical thinking, creative thinking, and problem solving (Launch Pad, 2001).

Barry (2012) outlined ten skills that are required to succeed in the twenty-first century, which include critical thinking skills, communication, leadership, collaboration, adaptability, competitiveness and accountability, innovation, global citizenship, entrepreneurial skills and spirit, and the ability to access, analyze, and synthesize content. Students will be prepared for global economic struggle through education in the twenty-first century. According to the Partnership for 21st Century Skills, 21st-century learning must teach four skills: communication, cooperation, critical thinking, and creativity. In addition, Frydenberg and Andone (2011) suggested that everyone needs critical thinking abilities, digital literacy skills, information literacy, media literacy, and mastery of information and communication technologies in order to face up to learning in the twenty-first century.

Derilo (2019) found in a study that students' academic achievement in Mathematics is related to their degree of Basic Critical Thinking Skills (BSPS), but not to their level of Integrated Critical Thinking Skills (ICTS). This implies that when a student's BSPS are improved, he may be able to do better in Mathematics. Similarly, students with a low level of critical thinking skills might expect poor academic success.

2.4 PBL and Critical Thinking Skills

Numerous research suggest that problem-based learning can be applied to a learning content if educators see the need. Critical thinking is the ability to think logically, coherently, and rationally while correctly identifying the connections between and among ideas and concepts. Observing, analyzing, inferring, communicating, and problem-solving are all skills that underpin critical thinking. Being able to think critically necessitates having the ability to creatively uncover connections between things. Allowing pupils to think outside the box fosters their curiosity and allows them to benefit from a wider range of learning opportunities. When comparing, students

should be able to tell whether things, thoughts, or ideas are connected or not solely by looking at how different or similar they are. Certain problems have a pattern that makes them easier to solve than others. Critical thinking abilities that have been developed make it easier to recognize this pattern, giving the student less time to solve it. Critical thinking abilities were an effective technique of improving students' grasp of mathematics ideas since they assisted in perceiving, analyzing, evaluating, and presenting facts in a logical and sequential manner (Chukwuyenum, 2013).

Activity materials based on PBL may include individual investigations, collaborative investigations, and the presentation of assignments (Arends, 2007). Individual investigative exercises allow students to discuss non-routine mathematics topics that may improve critical thinking skills (NCTM, 2000) while group exercises may provide opportunities to exchange ideas, connect and inform others about mathematics problem-solving strategies. Encouraging students to communicate and interact with others is very important in building critical thinking skills (Jacobs, 2012). By presenting assignments, students can practice and get used to speaking in public with confidence to communicate ideas (Arends, 2007).

When the role of teachers is facilitators rather than teachers (Arends, 2007), students are therefore expected to be independent, self-control and to evaluate their thinking (Facione, 2011). Students are taught to have the ability to identify and analyze the information in a given problem, especially the situation that are complex and ambiguous, and students are able to analyze the information to assess the justification. Therefore, the activities in the materials can encourage students to identify and interpret information, information analysis, and evaluation of the evidence and arguments. Thus, an intervention may be made for them, through a learning approach.

This learning approach may be in the form of a strategy or an activity material. Mendoza (2018) describes effective learning material as to learning experience, learning outcomes, effectiveness and efficiency, and user-friendliness. The congruence of the learning material to PBL approach was lifted from Hadley (2012). The collection of students' knowledge and personal experience, the significant and essential learning that students have achieved and can reliably demonstrate, and the usefulness, value, efficacy, and a well-defined structure and organization of the content are essential to determine the effectiveness of the learning material. These qualities will be of consideration on the level of critical thinking skills of the learners. Consequently,

components of critical thinking skills in mathematics can be measured by observation, analysis, inference, communication and problem solving of the evidence and arguments (Facione, 2011).

Aliliran (2016) concludes that PBL can actually contribute meaningfully to the positive development of creative and critical thinking skills in mathematics and science in a face-to-face classroom set up. But the gap has been identified whether PBL can still be of significant contribution to the said skills development if it will be focused solely on mathematics and critical thinking skills only and is applied not as a strategy but used as a learning material.

3. Methodology

3.1. Research Design

This study used experimental one group pretest-posttest research design. It is an experimental research design characterized as simply the attempt to establish relationships and check the development of specific skills (Creswell, 2012) through a systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness. A PBL material was used to test if there is an improved critical thinking skills of the Grade 10 students in Mathematics.

3.2. Participants of the Study

Participants of this research were 10th Grade students of an integrated high school in the Philippines. Considering that there is only one section conducting online class, which consist of 38 learners, they were purposively chosen as sample group. Purposive sampling, also known as judgmental, selective, or subjective sampling, is a non-probability technique based on characteristics. In this study, participants must be Grade 10 students who are under the online delivery of remote instructions (Crossman, 2020).

3.3. Research Instrument

The study used two main instruments: a survey questionnaire and a teacher-made test for Critical Thinking Skills. The survey questionnaire was primarily used to measure the perception of the respondents as to the PBL material. It is divided into five sub-indicators, namely learning experience, learning outcomes, effectiveness and efficiency, user-friendliness, and congruence.

Each sub indicator has five statements each rated using a Likert Scale ranging from 1 to 4, with 4 being the highest.

A teacher-made test for Critical Thinking Skills has five parts, one for each skill: observing, analyzing, inferring, communicating, and problem–solving. Fifteen (15) points were allotted for each skill with a total of 75 points. The test was content validated by experts. A table of specifications was also provided to highlight the distribution of test items per skill.

3.4. Research Procedure

The study covered three phases: the pre-assessment, the implementation and the post assessment stages.

For the pre-assessment, the research instruments were validated through presentation to a panel of experts. After securing the necessary permission from relevant offices, learners were given the teacher-made, expert-validated critical thinking skills test in the form of a pretest. This was done to measure the initial level of skills of the learners.

The implementation stage was the center of the study. In this phase, the researcher used the PBL material on a regular basis for six (6) weeks for quarter 3 of school year 2021 - 2022. The problem-based enriched learning material was applied in three approaches: individual investigations, collaborative investigations or presenting assignments. The approach was determined based on the nature of the lessons. It used one or combination of two or more of the approaches. As usual, the material starts with the learning targets covered by the Most Essential Learning Competencies and the Specific Learning Objectives. It was followed by an activity, which served as the springboard of the lesson discussion and highlighted the different approaches – though the approaches were also applied to other parts of the lesson. After the activity, it allowed students to explore on the lesson and then finally they were assessed through process questions aligned with the PBL approach.

In the post assessment, the respondents took the critical thinking skills test as well as answered the evaluation questionnaire for the PBL materials to identify its strengths and different areas for improvement. From the gathered results, data analysis was performed.

3.5. Statistical Treatment of Data

To decide on the actual results of the study and its findings, descriptive and inferential statistics were used. In order to describe the perception of the respondents as to the use of PBL Materials, mean and standard deviation was used. Frequency and percentage were applied to describe the level of skills of the respondents before and after the use of PBL materials. For the inferential statistics, Pearson-moment product correlation was used to reveal whether the perception of the learners relate significantly to their level of critical thinking skills. To find whether there is a significant difference in the participants' level of critical thinking skills before and after the use of PBL materials, paired samples t-test was applied. All inferential statistics were done at five percent (5%) level of significance.

4. Findings and Discussion

Table 1

Students' Evaluation of the PBL Material Quality

Indicators	Mean	SD	Remarks
Learning Experience	3.80	0.20	With high quality
Learning Outcomes	3.23	0.55	With quality
Effectiveness and Efficiency	3.27	0.46	With quality
User-friendliness	3.52	0.39	With high quality
Congruence	3.72	0.31	With high quality

Legend: 1.00 to 1.49 (With poor quality); 1.50 to 2.49 (With low quality); 2.50 to 3.49 (With quality); 3.50 to 4.00 (With high quality)

Table 1 presents the summary of the effectiveness of the PBL material. The result indicates that generally, there is a very positive perception on the quality of the material. On the five indicators used, three indicators, learning experience, user – friendliness and congruence all had a mean of above 3.50, thus considered with high quality while the remaining two indicators, learning outcomes and effectiveness and efficiency have a mean value of between 2.50 to 3.49 which interprets as with quality.

For learning experience, the students found it very much effective because the material has meaningful learning opportunities which were thought to be of great significance to the learning

that happened inside and outside of the classroom. It is supported by the study of Aleong (2012) that in order to have high quality learning experiences the teachers can control, direct and influence the students through planning and implementing the curriculum which will make students journey of learning worthwhile.

Learning outcomes also have a verbal interpretation of 'with quality.' This result is similar to the study of Aziz et al. (2012) that majority of the students find learning outcomes valuable because they use them in their studies in many ways. Since the ultimate goal of education is the learning outcomes, this has been the primary consideration in crafting and designing the PBL material. Competencies were anchored on the curriculum guide, which enumerates the desired competencies for each subject for a particular grade level.

In terms of effectiveness and efficiency, it also has a mean that translates to with quality. Since an initial assessment of what has been done and what needs to be done has been made, students perceived the PBL material as a means to address their needs and its topics are made very timely. Kaiser (2020) mentioned in his study that in order to make effective and efficient learning possible, then the focus must be on the students, models of learning and techniques to be used in teaching which can then improve and compliment the traditional approach like lecture or expository instruction.

In a digitally inclined world, students find technology as a means of interaction, socially and academically. Socially through gaining friends and academically as a strategy for teaching as used by some or most teachers. In the study conducted by Simui et al. (2017), they enumerated the key elements that an instructional designer needs to consider including presentation and layout of content, inclusion of real-life situations, and use of interactive language. These elements were considered in designing the learning material used in this study, thus students find it user-friendly. This result is supported by the study of Jayaram and Dorababu (2015), which emphasized that the focuses of learning materials are the flexibility of the process, friendly and informal climate in numerous learning situations, the use of experience, and the enthusiasm and commitment of students as well as the teachers.

The study claims that the material is of high quality. According to Maranan (2020), the quality of a material is also related to the effects it provides to the learners. When teachers are able to craft learning materials that are tailored to the needs, capacities and needs improvement of learners, they are expected to perform better. At the onset of the pandemic, teachers have shifted

from being end-users of learning materials to being developers. Thus, capacity building for teachers in developing learning modules must be strengthened.

Table 2

Pretest and Posttest Scores on Critical Thinking Skills

Grade	Pre-Test		Post-Test		Remarks
	F	%	F	%	
Observing					
90 and above	11	28.95	38	100.00	Outstanding
85 to 89	25	65.79		0.00	Very Satisfactory
80 to 84	2	5.26		0.00	Satisfactory
75 to 79		0.00		0.00	Fairly
74 and below		0.00		0.00	Needs improvement
Analyzing					
90 and above		0.00	37	97.37	Outstanding
85 to 89	2	5.26	1	2.63	Very Satisfactory
80 to 84	8	21.05		0.00	Satisfactory
75 to 79	26	68.42		0.00	Fairly
74 and below	2	5.26		0.00	Needs improvement
Inferring					
90 and above		0.00	35	92.11	Outstanding
85 to 89		0.00	3	7.89	Very Satisfactory
80 to 84	4	10.53		0.00	Satisfactory
75 to 79	19	50.00		0.00	Fairly
74 and below	15	39.47		0.00	Needs improvement
Communicating					
90 and above		0.00	13	34.21	Outstanding
85 to 89		0.00	23	60.53	Very Satisfactory
80 to 84	5	13.16	2	5.26	Satisfactory
75 to 79	21	55.26		0.00	Fairly
74 and below	12	31.58		0.00	Needs improvement
Problem- Solving					
90 and above		0.00	10	26.32	Outstanding
85 to 89		0.00	25	65.79	Very Satisfactory
80 to 84	6	15.79	3	7.89	Satisfactory
75 to 79	22	57.89		0.00	Fairly
74 and below	10	26.32		0.00	Needs improvement

In terms of observing, the test scores revealed that before the learners' exposure to the PBL, the majority of their scores fall under very satisfactory, with eleven (11) students being able to

have an outstanding score and only two (2) got a score of satisfactory. After the use of the learning material, all of the learners were able to get outstanding scores. The question for observing revolved around identifying the main problem and deciding on the most significant values that can be derived from the problem. These results imply that after the use of the PBL Material, the students find it easier to come up with a central problem from a given situation and are able to make deductions on the values presented.

In terms of analyzing, initial scores are greatly concentrated on the range of fairly that covers test scores from 75 to 79. This implies that they are only able to present the formula, substitute the proper values and solve for the final answer. However, after the use of the PBL Material, the concentration of the scores have drastically shifted to the 90 and above or the outstanding level. The outstanding level of analyzing shows that aside from giving the appropriate values, they can also think of other ways of presenting the analysis, such as the use of a venn diagram. They were also able to explain what these values mean and what their diagram is all about. The PBL Material, specifically the questions, examples and discussions, enabled the learners to use their analyzing skills.

The table also shows that the scores for inferring skills fall between needs improvement and fairly with score range of 75 to 79 and 74 and below before the teacher used the PBL Material. For those who did not meet the expectations, they only wrote numbers or digits found in the situation. For those who scored fairly, they simply showed their final answers. After exposure to the materials, there scores can be described as outstanding. They can present the values and how they can be used for the solution, and they were able to briefly and concisely provide discussion on what they need to do to arrive at a precise and accurate answer. They were able to explain further the context of their calculations after being exposed to the learning material. Their scores were then concentrated on the outstanding bracket, ranging from scores of 90 and above.

As to communicating, the scores are generally close to that of inferring likely found between needs improvement and fairly for the pre-test but for the post-test, the students were more of very satisfactory and outstanding, with 60.53% and 34.21%, respectively. This leads to the conclusion that after the use of the PBL Materials, the learners find themselves more open to communicating to their fellow students and to their teacher. This is supported by the personal message from a student respondent who said that they had more time talking when the PBL

Material was used in their online class. It served as a springboard for learners to be communicative about their thoughts and ideas specially when solving problems.

For the problem-solving skills, the same can be said as for communicating. The general scores are found in the two lower brackets before the students' exposure to the learning material, needs improvement and fairly and were raised to very satisfactory after the use of the material. Specific skill observed was use of percentage, decimals and fraction in presenting relevant relationship on how the problem may be solved but still cannot elaborate on how the numbers can be applied in relation to the problem given. There were also 26.32% of the population that were able to perform outstandingly. It is therefore concluded that after the use of the PBL Material, the students are more versed in applying the solutions in a real-life context.

Table 3

Relationship between the Qualities of PBL Material and Level of Critical Thinking Skills

Qualities of PBL Material	**Critical Thinking Skills**				
	Observing	Analyzing	Inferring	Communicating	Problem Solving
Learning Experiences	0.130	-0.070	0.397*	-0.363*	0.357*
Learning Outcomes	0.014	0.200	-0.298	0.539**	-0.379*
Effectiveness and Efficiency	0.059	0.224	-0.314	0.352*	-0.149
User – friendliness	-0.096	0.213	-0.294	0.373*	-0.182
Congruence	0.439**	-0.352*	0.545**	-0.378*	0.419**

*Legend: *. Correlation is significant at the 0.05 level (2 – tailed).*
***. Correlation is significant at the 0.01 level (2 – tailed).*

For the test of relationships performed between the quality of the PBL materials and CTS, it revealed learning experience significantly relates to inferring, communicating and problem solving, but has no significant relationship to observing and analyzing. This elucidates that learning experience of the students, as provided for in the learning material, are greatly varied and utilize situations and problems that are highly relatable to the skills of the learners. This further implies that inferring and problem solving are positively affected by learning experiences. Learning experiences focused on the vocabulary and comprehension and independent and collaborative learning which are related to communication, adapting to needs, interests and

abilities that are the focused of inferring and individual competencies of learners in terms of problem solving.

Positive significant relationship between learning experiences and inferring and communicating have been found. This means that the high perception of the learners in the material is reflected in their inferring and problem solving skills. This further implies that the learning experiences provided by the PBL Material are found by the students to be significantly contributory to their level of inferring and communicating skills and that the students who took the critical thinking skills test are also the ones with developed inferring and communicating skills. This is supported by the high perception of the respondents and their scores. This is further supported by some parts of the PBL Material where it provided varied learning experiences as reflected in the activities provided in the material. The significant negative correlation between the learning experiences and communicating imply that the students who positively perceived the learning experiences in the material were the ones who got the low scores for the said skill. This leads to the conclusion that communicating skills of the learners are not heavily affected by the way they perceive the learning experiences in the learning materials.

Learning outcomes also significantly relate to the specific skills communicating and problem solving. Positive significant relationship for communicating and negative significant relationship for problem solving. The students who are aware of the learning outcomes as specified in the materials scored satisfactorily to the communication skills test. This may be true because by allowing the students to present their assignments to class, they were able to find the level of communication relevant in achieving their learning goals. Likewise, the open channel of communication between the teacher and the learner, and amongst learners made them share a common goal for learning. For the problem-solving skills, the learners who perceived highly of the learning outcomes had low scores for the skill. This entails that since learning outcomes are very much specific in the material, yet very broad in the context of problem solving, they are having a hard time connecting the learning outcomes to real-life situations.

Communicating significantly related to the effectiveness and efficiency and user-friendliness as primary desired qualities of the learning material. Effectiveness and efficiency discusses about the qualities of the learning material in terms of addressing the needs of the learners. These learners have scored highly were able to perceive the material as effective and efficient in addressing their needs. Effective in the sense that it provided a variety of examples and

efficient as it can readily answer questions emerging from the learners as the discussion progresses. With the use of less texts and more of graphical presentations and images, students were able to understand better the lessons. The step-by-step procedures on performing the more complex solutions also helped the learners. This may be the reason why the user – friendliness of the material significantly related to the communication skills of the learners. As claimed by Suarez (2018), students are more inclined into seeing graphical representations rather than reading texts.

All Critical Thinking Skills showed significant relationship to the level of congruence. Since PBL material has been proven to develop critical thinking skills as a teaching strategy, and now when applied in a learning material, the results support and further strengthen these claims. This leads to the conclusion that the more congruent the material becomes, the more it will be able to develop the level of Critical Thinking of the student respondents.

Table 4

Test of Difference in the Critical Thinking Skills Before and After the Use of PBL Material

Critical Thinking Skills	Test	Mean	SD	Paired Differences					t	Df	Sig. (2-tailed)
				Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Observing	Pretest	89.18	3.46	-7.42	4.77	0.77	-8.99	-5.85	-9.594	37	0.000
	Posttest	96.61	2.26								
Analyzing	Pretest	78.82	3.04	-17.24	3.34	0.54	-18.33	-16.14	-31.809	37	0.000
	Posttest	96.05	1.52								
Inferring	Pretest	76.21	3.13	-18.58	3.68	0.60	-19.79	-17.37	-31.116	37	0.000
	Posttest	94.79	2.42								
Communicating	Pretest	77.05	3.18	-12.11	3.57	0.58	-13.28	-10.93	-20.902	37	0.000
	Posttest	89.16	2.57								
Problem Solving	Pretest	76.71	2.99	-12.24	4.30	0.70	-13.65	-10.82	-17.559	37	0.000
	Posttest	88.95	2.84								

Legend: Sig. < 0.05 significant

Table 4 shows that all of the Critical Thinking Skills, observing, analyzing, inferring, communicating and problem-solving, are significantly different, in favor of the posttest as reflected by the values of the mean.

For observing, there has been a significant difference based from the values of the mean and standard deviation of the pre and posttest. It suggests that initially there were students who struggled in finding the main problem and identifying the pertinent values. Therefore, observing has been improved because the PBL Material used guide questions that allowed them to choose

which values such as the given, the operation to be used and the processes they need to undertake are useful and which are otherwise.

In terms of analyzing, students were able to gain a systematic view of how problems may be solved. They used a variety of methods including graphical representations, direct substitution and solving to show that all these solutions ultimately lead to a single final answer. Students also had the chance to collaborate with each other so that they can check other students' ideas.

As to inferring or the ability of the learners to generate explanations, they are already capable of generating clear and understandable explanations presented in a logical manner after being exposed to the PBL Material. One reason for this is that the lessons are anchored on the most essential learning competencies and that the lessons were tailored to the needs of the learners. This is consistent with the findings of Hart and Martin (2018) that when it comes to inferring skills, it is better that students be presented with a general problem, have them solve it and explain, then allow them to explore the context of their explanations.

With regards to communication, the students really had anxiety toward the subject and was coupled with their intimidation with the teacher. This has resulted to low pretest scores and was admitted by one of the respondents. But as the students were exposed to the use of the PBL Material and were subjected to activities wherein they would present their works, they gained more confidence and talked even better with their teachers and fellow students. They were also able to use their own words to get messages across based on how they were able to understand the problem and its context. Not only that, but they also showed that after computing, they are capable of explaining what these numbers mean.

The results also show that problem-solving skills have also been improved. It was observed by the researcher that the students have the skill of applying the meaning of the computed values in order to solve the problem at hand. For example, when the students were asked in one of the classes whether it would be better to have more goods or less goods in a sari – sari store, one of the students answered that having more goods would mean a greater probability that the goods the customers are looking for are in the store increases the chances of serving the customer. However, if there are less goods, it would have less probability that the store has what the customer needs.

5. Conclusion

This study aimed to determine the effectiveness of PBL material to the critical thinking skills of Grade 10 students in Mathematics. The study used experimental research design focused

on students' perception on the quality of the material and its effectiveness in improving the critical thinking skills of the students. The findings showed that PBL Material content are aligned with the learning outcomes, effectiveness and efficiency. For learning experience, students agreed to its user-friendliness and congruence. The pre-exposure tests scores were generally concentrated on the scales interpreting to needs improvement, fairly and satisfactory ranging from below 74 and 80 to 84. After the use of the PBL material, the scores raised to 85 to 89 and 90 and above ranges, very satisfactory and outstanding. This is true for all the Critical Thinking Skills that were tested. Significant relationships were found between learning experiences and inferring, communicating and problem-solving. Learning outcomes related significantly to the communicating and problem-solving scores while effectiveness and efficiency and user-friendliness both have significant relationship to communicating. All Critical Thinking Skills have significant relationship to Congruence. The scores before and after exposure to the PBL material were significantly different in terms of observing, analyzing, inferring, communicating and problem-solving. All scores for the different skills are in favor of the posttest.

This study concludes that if the material can further enhance the desired qualities, learning experiences, learning outcomes, effectiveness and efficiency, user-friendliness and congruence, it is likely that the learners will have a higher level of Critical Thinking Skills. The PBL material, or the exposure to it, has developed the level of Critical Thinking Skills of the students. With these, this study suggests that the material can be used to develop the inferring and communicating skills of the learners by providing meaningful learning experiences as reflected by the significant relationship. The same can be said for learning outcomes, effectiveness and efficiency and user-friendliness which all related to communicating, with learning outcomes also relating to problem-solving. The congruence of the material to PBL also related to all the critical thinking skills. Thus, it is recommended that to strengthen these parts of the material to further develop the skills. All critical thinking skills were developed by the PBL material, leading to the conclusion that it may be used as a supplementary material which teachers can use in the delivery of the lessons. This may be further tested in different learning modalities implemented in the school.

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Community of Inquiry Framework in Basic Science Process During Synchronous Learning Modality

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Abstract

This study was grounded on the established Community of Inquiry (CoI) Framework to assess the behavior of students during the synchronous classes and its association with the Basic Science Process Skills (BSPS). The participants of the study were twenty-eight students from the seventh grade class of a public elementary school in the Philippines. The quantitative data were collected from the survey questionnaires while the pre-test and post-test were measured using a rating scale instrument facilitated via Google forms. Pearson-r was used to find the correlation among the variables while the T-test for the differences between variables. The results divided the CoI into three presences. The teaching presence, social presence, and cognitive presence with an acceptable mean, implies a good sense of community among the learners. Furthermore, few students' basic science process skills were advanced and proficient, while most were still approaching proficiency and developing levels. The constructs of the CoI Framework were associated with the basic science process skills for classifying. Similarly, there is a significant difference between the pre-test and post-test scores of the respondents in classifying and measuring. The results suggest that continuous exposure of the students to CoI during synchronous classes improves their ability to self-study during asynchronous classes.

Keywords: *Community of inquiry, basic science process skills, synchronous learning*

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1. Introduction

Over half of the world's children are still affected by partial or complete school closures one year after the COVID-19 pandemic began, and the health catastrophe caused over 100 million additional children to fall below the minimum reading competency level (UNESCO, 2022). While the majority of the talents were beginning to erode rapidly, the Department of Education (DepEd), publicized the official school calendar and activities for the years 2021-2022, applying blended learning as a new method of delivering education amidst the global health crisis. In the Philippines, a "*blended learning*" program that included online classes, printed materials, and lessons broadcast on television and social media was launched. According to the United Nations, whereas practically every other country has partially or reopened schools for in-person instruction, the Philippines has kept its schools closed since the pandemic began.

The Philippine educational system did not have a formal online platform for delivering formal instruction to the students until the break-out of the pandemic. Unfortunately, due to the impending calamity already spreading, education's future has become questionable. While online education is quickly evolving, more studies on students' experiences in online courses are needed (Panergayo & Aliazas, 2021). One topic that has been investigated in connection to the quality of the online learning experience is the cognitive, social and teaching presence that was just among the presences on the Community of Inquiry Framework (Garrison & Akyol, 2013). It is primarily well-researched because online learning has gained popularity worldwide due to technological advances and the increase of the internet.

The community of inquiry (CoI) framework is an essential and relevant concept for framing this research which may be applied to analyze and describe the three presences of the participants as they interact within the community of synchronous classes. As such, its main purpose is to evaluate the total experience of the Grade 7 students who took science online class built upon the CoI framework through cognitive, social and teaching presence and how would synchronous online modality enhances student's basic science process skills (BSPS). This study also examines the processes of synchronous learning through CoI structure as the primary lens for analyzing the content of synchronous learning modality towards enhanced BSPS. BSPS is an integral part of students holistically developing and managing their learning in science through their journey.

In the new education platform, problems arise from low expectations, inadequate understanding due to insufficient teacher and student interaction, and the number of students in an online class. The progress to web-based learning has affected teachers, learners and the learning

environment, which has also sparked debate on the applicability of online class. Although online classes are seen challenging as a result of educational structure, obstacles are identified to making online classrooms a reality. The epidemic has to light the need to enhance the educational system, which now provides an opportunity to do so (Aliazas et al., 2021).

Specifically, the study aimed to assess the effectiveness of synchronous online modality built upon the CoI framework towards BSPS enhancement, determine the pre-test and post-test scores of the respondents on BSPS, evaluate the significant relationship between synchronous modality built upon CoI and the BSPS, and evaluate the significant difference between the pre-test and post-test scores on BSPS.

2. Literature Review

Online courses are becoming increasingly popular. Students are drawn to online classes because of the ease of participating at any time and from any location, but once enrolled, they may be unsatisfied with the experience (Moskal et al., 2010). One of the causes of this dissatisfaction is that online students sometimes feel cut off from the rest of the world. This gap might make it difficult for students to communicate and learn together. Furthermore, teachers have reported having difficulty encouraging online student interactions. As a result, there is a pressing need to develop online learning settings that can preserve a strong feeling of community while supporting students socially and cognitively (De Noyelles et al., 2010). In addition, chat rooms, instant messaging, and web conferencing with whiteboard, audio, and video capabilities can help synchronous collaboration (e.g., Blackboard Collaborate, Adobe Connect). According to Hsiao (2012), synchronous communication can help overcome some of the drawbacks of asynchronous learning environments, such as offering possibilities for instant feedback and assisting in the development of relationships between instructors and students.

Stenbom et al. (2012) introduced the relationship of inquiry framework, which is an adaptation of the community of inquiry framework for an online coaching context, to conceptualize the one-to-one learning environment of online coaching. According to Anderson (2017), the current CoI model's major flaw is that, while it aids in the construction and definition of a successful teaching model, it ignores the reality that the efficacy of teaching is equally dependent on the learners. As a result, the author agrees with Shea and Bidjerano (2010) that a new presence, the learner presence, should be included in the framework.

In online education research, several techniques for assessing learning processes have been considered by Garrison and Akyol (2013). The community of inquiry framework, which has been widely researched and validated, is regarded as one of the best and most popular models for evaluating online learning (Akyol et al., 2009; Jézégou, 2010). Kanuka and Rourke (2013) critiqued of the CoI framework considered the central indicator of a successful online learning experience to be *"deep and meaningful learning"* as *"the critical examination of new facts and the effort to make numerous connections with existing knowledge structures,"* contrasting it with surface learning, "the uncritical acceptance of new facts and ideas."

According to Garrison and Akyol (2013), the CoI framework is designed to support teacher and student reflection upon discursive behaviors in online environments to facilitate deep, meaningful learning. The philosophical premise of the COI framework is a collaborative constructivist approach to teaching and learning that comprises three interdependent structural elements: social, cognitive, and teaching presence. It is a relevant and significant framework to describe the three presences, namely social, cognitive and teaching, as the students participate in synchronous learning in an active community. The validity of the CoI has been tested by Swan et al. (2008).

2.1. Social Presence

Social presence refers to *par*ticipants' capacity to identify with the community, speak meaningfully in a safe atmosphere, and build interpersonal relationships by projecting their personalities (Weissman, 2010). However, social presence alone will not guarantee the establishment of critical discourse in online learning, and such discourse will be exceedingly difficult to emerge without a foundation of social presence.

Common goals and inquiries provide the basis of a sense of community. Furthermore, if the learning activities are knowledge acquisition and there are no collaborative tasks where students may benefit from the viewpoints of others, social presence is less critical (Picciano, 2021). In contrast, the issue here is the nature of social presence and how it must change as a course of study progresses. As important as it is to establish effective communication and social relationships, a community's long-term viability depends on the group's ability to speak openly and unify around a shared objective or purpose (Kabilan & Annamalai, 2022).

Emotional Expression. Emotion became one consideration for successful online learning, similar to face-to-face learning. Cleveland-Innes and Campbell (2012) include emotional expression as the fourth presence of the CoI framework and defined it as the "*outward expression of emotion, affect, and feeling by individuals in a community of inquiry, as they relate to and interact with the learning technology, course content, students, and instructors."*

In a study by Jiang and Koo (2020), recognition, emotions shared by the teacher, students and peers and directed effectiveness showed a strong need to make emotional connections. The study of Garrison and Akyol (2013) found that affective expressiveness declined over three periods, and group cohesiveness increased sharply. It might be claimed that collaborative activities boost students' sense of belonging to the group, which they were guided from an individual to a collective perspective. Furthermore, several of the students' responses to open-ended questions also indicated the significance of collaborative actions for their successful learning.

***Open Communication*.** A study by Chen (2014) discussed the interactivity of the students, which is a contributor characteristic of communication settings. Its definition implies subjectivity. Thus, interactivity is considered a parameter of a communication setting and not a medium. According to Gunawardena et al. (2018), an online wisdom community's lifeblood is communication. A community's identity and relationships are formed and strengthened via good communication. Good communication sets the foundation for transformative learning by offering clarity of goal and motivation.

Group Cohesion. A study by Chen (2014) states that immediacy is associated with the connectedness and closeness one feels with another. Group cohesiveness can be seen in the students who feel a sense of belongingness and commitment. She unveiled the valuable relationship between teacher nonverbal immediacy and students' effective learning. Non-verbal immediacy behaviors include smiling and eye contact when talking to students.

2.2. Teaching Presence

Teaching presence refers to designing, assisting, and leading cognitive and social processes to achieve personally meaningful and educationally worthwhile learning outcomes (Garrison, 2016). According Weissman (2017), the value of teaching presence in the CoI framework and the world of online education is the subject earlier studies. Previous studies have verified teaching presence in an asynchronous setting. Teaching presences play a big part in students' overall

learning during synchronous classes. Rules, techniques and various methods incorporated by the teacher during synchronous classes help identify students' development.

Instructional Management. When examining teachers' self-efficacy beliefs, classroom management is one of the six primary domains of teacher functioning. Teacher effectiveness has been linked to teachers' classroom actions, levels of effort, aspiration, preparation, and organization, as well as their tenacity and resilience in difficult situations (Yildiz, 2017). Martin (2016) discusses that teachers' control, rules, best instructions, instructional styles, and managing students' misbehavior are under instructional management. Futch et al. (2016) add that clear instructions, feasible assignments, and applicable activities support students' total learning outside and during classes.

Lang (2013) refers instructional management as teachers' actions, including communicating and demonstrating classroom rules, allotment of learning topics, objectives and materials and keeping an eye on student output and homework submission. As such, good instruction implies good classroom management (Yildiz, 2017) encompassing classroom management as more comprehensive than student discipline. The three aspects of instructional management include teacher preparation, the physical environment and various strategies for presenting lessons. Misbehavior and problems might not arise when they are prevented with best planning, curriculum pacing, and clear instruction that engages students in academic subjects.

Building Understanding. Building understanding among the learners made their attention span longer during classes and piqued their curiosity, creativity, and knowledge acquisition. It engaged in the learning process, where they explored different concepts and developed a sense of community among them. Within *"building understanding,"* one category/aspect under teaching presence. According to Anderson et al. (2012), building understanding is a method for students to interact and expand on the knowledge offered in the course's instructional materials. The educator may employ techniques such as communicating meaning, highlighting areas of agreement and disagreement, and achieving consensus and understanding (Arbaugh, 2008). As a result, facilitating discourse necessitates the instructor to review and comment on student comments, raise questions and make observations to move discussions in an intended way, maintain the discussion going smoothly, mark out unresponsive students, and try to limit the activity of dominating students who may be disadvantageous to the learning of the students.

Direct Instruction. Relating current and relevant issues during discussions got students' interest and attention and optimized learning feedback that helped teachers meet learning outcomes. According to Hatziapostolou and Paraskakis (2010), formative feedback in the students' learning is instrumental. Providing high standard feedback and ensuring engagement helps and encourages learning. Feedback must be timely, customized, manageable, direct and motivating.

Anderson et al. (2012) describes direct instruction as the instructor's intellectual and scholarly leadership, which included sharing their subject matter expertise with the pupils. A subject matter expert, not just a facilitator, should perform this function because of the requirement to diagnose comments for appropriate comprehension, infuse sources of information, guide conversations in productive directions, and scaffold student knowledge to take it to a new level. Direct instruction is concerned with the indicators that measure the discourse and the efficacy of the educational process, in addition to transferring information by a topic expert. In addition, Yang et al. (2010) emphasizes that questioning and collaborating have been identified as helpful strategies for motivating pupils, promoting communication skills, and assisting in constructing meaning. This is supported by Weissman (2017) describing questioning as a powerful strategy for encouraging learning and serves as a foundation for thinking since it motivates students, focuses their attention, and

2.3. Cognitive Presence

Cognitive presence is the amount to which learners may generate and reinforce meaning in a critical Community of Inquiry via persistent contemplation and dialogue (Garrison & Akyol, 2013). Garrison et al. (2001) describe cognitive presence as the extent to which learners can construct and confirm meaning through sustained reflection and discourse. Cognitive presence in online learning is developed as the result of a four-phase process: 1) a triggering event, in which some topic or problem is discovered for further investigation; 2) exploration, in which students investigate the subject individually and collectively via critical reflection and discussion. 3) integration, in which learners generate meaning from the concepts developed during the inquiry; and 4) resolution, in which learners apply newly acquired information to educational or workplace situations.

2.4. Theoretical Framework

The CoI framework (Garrison & Akyol, 2013) proposes that online learning is the participation of a community in the course of an inquiry based on the essential elements of cognitive presence, social presence, and teaching presence. Knowledge construction is a process in this investigation carried out by cognitive, social, and teaching presence. Each of the three types of presence, has its qualities but depends on the others. The environment is shaped by social and teaching presence, with active social presence encouraging discourse and thereby increasing cognitive presence. Direct facilitation and instruction are used to give the material needed to enhance cognitive presence. The three aspects of the CoI are interconnected and work together to create a positive, practical, engaging, and socially beneficial educational experience.

The CoI is a hypothetical framework for creating ideal internet learning environments that stimulate fundamental thinking, inquiries, and conversation among students and educators (Garrison, 2016). Instructors can use instructional models to relate the findings of instructive research to the practical job of educational planning, improvement, and sequencing of informative encounters to improve learning (Cooper & Scriven, 2017). An ideal CoI includes a "*cohesive and interactive community of learners whose aim is to critically investigate, build, and validate useful information*" (Garrison & Vaughan, 2008, p. 9). The social dynamics, connections, and collaboration that exist to generate an atmosphere that encourages inquiry are referred to as "community." The "process of generating meaning via personal responsibility and choice" is referred to as "inquiry" (Garrison & Vaughan, 2008). According to Garrison (2016), online academic staff and students collaborate to create a productive online learning environment in which knowledge is generated by skillfully marshaling several types of presence.

Social Presence. Participants' capacity to identify with the community, speak meaningfully in a safe atmosphere, and build interpersonal relationships by projecting their personalities (Garrison, 2016). Social presence, formerly regarded as a novel theoretical approach (Short et al., 1976), has been investigated in several different settings. People involved in this conversation are separated by a significant amount of time and space.

Cognitive Presence. The amount to which learners may generate and reinforce meaning in a critical CoI via persistent contemplation and dialogue (Garrison, 2016).

Teaching Presence. *This includes d*esigning, assisting, and leading cognitive and social processes to achieve personally meaningful and educationally worthwhile learning outcomes (Garrison, 2016).

3. Methodology

This study used a quasi-experimental research design, a quantitative survey descriptive analysis and correlational research to investigate the effectiveness of synchronous learning modality built upon the CoI framework towards the basic science process skills development and enhancement of the students. It involved collections of quantitative information tabulated along a continuum in numerical forms, such as scores on a test (Maranan, 2017). It entails collecting data that characterizes the activities and organizing, tabulating, depicting, and interpreting the data collected.

The study participants comprised only 28 enrolled online students from Grade 7 of a public integrated school in the Philippines. The respondents of the study were chosen by purposive sampling, a judgmental, selective, or subjective sampling, where a sample is a non-probability sample selected based on population characteristics and the study's objectivity (Crossman, 2017).

The study was conducted between March and April 2022. The data gathering tools for this study were the researcher-made lesson plan, the pre-assessment and the post-assessment test to determine the student's performance in basic science process skills. The constructed lesson plans employed the three presences of the CoI that are very important in an online class to have meaningful learning. The study coverage was weeks 4, 5, 6, 7, and 8 of the third grading period of Grade 7 Science. The second instrument was the assessment tool, consisting of 60-item questions in the pre-and post-assessment tests that measure the basic science process skills of the students. The last instrument was the adapted CoI survey questionnaires.

The research applied the independent and dependent conceptual models. Independent variables included the teaching presences such as instructional management, building understanding and direct instruction; social presences such as emotional expression, open communication and group cohesion; cognitive presences such as triggering events, exploration, resolution and integration. The dependent variables were the basic science process skills such as observing, communicating, classifying, measuring, inferring and predicting.

4. Findings and Discussion

Table 1

Level of teaching presence

Teaching Presence	Mean	SD	Verbal Interpretation
Instructional Management	4.10	.85	Agree
Building Understanding	3.96	.96	Agree
Direct Instruction	3.88	.88	Agree

Under instructional management, majority of the respondents agree with all the indicators. Based on the composite mean of 4.10 and standard deviation of .85, it was indicated in the verbal interpretation, *"agree"* is the major answer from the respondents. Classroom management played an important role during the duration of the synchronous class, as the teacher set clear instructions beforehand. These are the same findings of Futch et al. (2016) and Hatziapostolou and Paraskakis (2010) emphasizing on clear instructions and effective communication. The data imply a uniform response from teachers sets a tone for classroom atmosphere and instructional management that assert the findings of Martin (2016) and Oliver and Reschly (2007).

Under building understanding, most respondents agree with all the indicators evidenced by a composite mean of 4.01 and standard deviation of .72. Guiding students, encouraging and helping them engage with the learning process led to the successful integration of learnings. Positive reinforcement minimizes negative behaviors and boosts self-confidence to build total learning experiences. The data imply a uniform response where the teacher could connect ideas, clear up misconceptions, and ask the class for clarification (Arbaugh et al., 2010). Furthermore, to strengthen blended learning, teachers and students must have support and enrich different resources (Futch et al., 2016). Building understanding among the learners made their attention span longer during classes and piqued their curiosity, creativity, and knowledge acquisition.

Most respondents agree with all the indicators under direct instruction based on the composite mean of 3.88 and standard deviation of .88. Feedback assists students' progress and

tends to become more productive once accurate and inaccurate things are cleared up. It also improves students' confidence, active participation and elicits the power of good conversation.

Table 2

Level of social presence

Social Presence	Mean	SD	Verbal Interpretation
Emotional Expression	3.74	.74	Agree
Open Communication	3.65	.79	Agree
Group Cohesion	3.50	.68	Agree

Under emotional expression, majority of the respondents agree with all the indicators as indicated by a composite mean of 3.74 and standard deviation of .74. Inclusivity was practiced during the synchronous class, where students felt a sense of belongingness. Social interaction was also practiced as the students met and greeted their classmates on the first day. This is similar to the dynamic experience of social presence in emotional presence assessed by Cleveland-Innes and Campbell (2012) that emotional presence is more than simply an expressive reaction manifested through social presence; it also underlies the overall online experience. Expressing emotions appropriately made them feel a sense of belongingness among other students. The power of students' connectedness for learning is what makes social interaction possible and attainable.

Under open communication, most respondents agree with all the indicators based on the composite mean of 3.65 and standard deviation of .79. Most of them found the online class comfortable. The most talked about issue for social presence in online discussion is setting the climate and bearing the sense of community vital to building strong communication and learning. This was evident in the study of Arbaugh et al. (2010) that learning perception could affect once learners feel fear of interacting with the teacher or classmates online. Communicating with the students openly is still one of the best ways to establish a sense of community during an online class. Teachers communicate one-to-one or one-to-many while students in many ways, such as group chat, emails, Google classroom etc. (Richardson & Lowenthal, 2017). Student's level of connectedness determined how they are motivated to take active participation during synchronous class.

Under group cohesion, the majority of the respondents agree with all the indicators with a composite mean of 3.50. Acknowledgment shows respect for someone's idea, recognition of someone's contribution and makes them feel that they exist. In addition, a sense of collaboration is significant for creating growth and improving student outputs. Collaboration improves the group strategy, teamwork, suggestions and opinions of the students in the online class, which leads to deeper learning. This supports the study of Arbaugh (2008) that interpersonal communication increased students' sociability during synchronous classes, leading to more interaction.

Table 3

Level of Cognitive Presence

Cognitive Presence	Mean	SD	Verbal Interpretation
Triggering Event	3.88	.97	Agree
Exploration	3.76	.78	Agree
Integration	3.95	.71	Agree
Resolution	3.85	.63	Agree

Under triggering event, the majority of the respondents agree with all the indicators based on the composite mean of 3.88. Strategies for properly delivering the lesson became essential during the synchronous classes. Asking many questions as a form of motivation caught students' interest until the end of the class while providing them problems led to further inquiries. Triggering event catches students' attention, piques their interest and motivates them. The art of questioning is critical in this part. Fiock (2020) showed that activities related to inquiry and questioning must be seen in this part of cognitive presence for best results.

Under exploration, most respondents agree with all the indicators based on the composite mean of 3.76, interpreted as "agree." Brainstorming was also practiced during synchronous class, allowing students to think without limitations and fear of being judged. The exploration phase is about exchanging information and ideas, where students explore different views and learn through critical reflection and serious discussions of a particular lesson. Similar to the findings of Guo et al. (2021), exploration phase greatly affects students' performance. This phase used different sources of information and made them explore problems posed during an online class. Encouraging numerous perspectives and conversations led to an understanding of different topics.

Under integration, most respondents agree with all the based on the composite mean of 3.95. Different activities were done during the synchronous classes wherein students were given a chance to express their opinions and insights. In addition, reflections were also seen during the class as they encouraged a better learning experience. As integration emphasizes different ideas and thoughts during the exploration, similar findings were observed from Akyol and Garrison (2008) that the apparent rise of activity around the integration phase was due to the expansion of knowledge from diverse sources. Students' ability to support and integrate their thoughts using multiple resources improved as they began to employ additional sources. The integration of learnings ended with reflections that served as a fundamental concept in an online class.

Under resolution, the majority of the respondents agree with all the indicators with a composite mean of 3.85. Applying real-life ideas in lessons support good classroom management as engagement increases (Medina & Del Rosario, 2022). The resolution phase, where the students apply their gained knowledge and learnings to their everyday lives or workplace settings, emphasizes Akyol and Garrison (2008) findings that it necessitates enhanced teaching presence to explore and diagnose various concepts so students may go to a higher level of thinking while developing their thoughts.

Table 4 shows the overall BSPS results for both pre-test and post-test. The result implies balanced scores of the respondents who got a 7-10 and 0-4, and there is an urgency to help the respondents come up with greater BSPS. While under a score rating of 5-6 with remarks of *"approaching proficiency,"* there are no changes in pre-test and post-test.

Table 4

Overall Performance of Basic Science Process Skills

Rating	Pre-test		Post-Test		Remarks
	F	%	F	%	
74 & Below	7	25.0	7	25.0	Beginning
75-79	6	21.4	4	14.3	Developing
80-84	6	21.4	6	21.4	Approaching Proficiency
85-89	5	17.9	4	14.3	Proficient
90-100	4	14.3	7	25.0	Advanced
Total	**28**	**100**	**28**	**100**	

The data reveal that respondents were improving to a good result, which had a big chance of progressing towards proficiency and advanced as they were continuously exposed to the COI framework during their online class. The overall BSPS of the students was inadequate similar to the findings of Zulkarnaen et al. (2018) that mastery of information and science process skills is insufficient to train students to be creative and science-driven but needs other skills.

The obtained data indicate no change in the respondents who got a score of 0-2 from the pre-test to post-test exam results. This means respondents who were in a heterogenous group of students were maybe unsure of their chosen mode of learning. Respondents had difficulty grasping the lessons due to limited time and resources. However, respondents with a score rating of 3-4 with a remark of *"developing"* apparently decreased in number and added improved to 9-10. This gives a positive implication on utilizing the COI framework during synchronous learning modality. To address the problems reflected in the results, Ango (2002) suggested that communication skills must be taught and studied early in science learning and teaching. Thoughts and ideas must be communicated for better outcomes and students' awareness. The flexibility of online classes does not mean they provide efficient and purposeful learning; hence, individual differences of the students affect their learning styles (Law et al., 2022).

The table 5 shows the relationship between students' perception on CoI Framework during synchronous classes and the students' BSPS. Only classifying skill has significant relationship with the instructional management of teaching presence, emotional expression, open communication, and group cohesion of social presence, exploration and integration of cognitive presence. Classifying, an essential skill where students categorize or group things by recognizing their similar and different properties, is also rooted within the rest of the skills especially observing, good observations lead to progressive growth of the other skills, being keen observer made you to be aware and be more vigilant of the things around us.

As gleaned on the table, most of the sub-variables under the COI framework are significantly related with only one science process skills which is classifying. This means students who can classify satisfactorily can also understand the lesson well. The result also imply that the skill of grouping things gives an important mirror with the three presences of the COI framework.

Table 5

Correlation between CoI Framework and the Basic Science Process Skills

Community of Inquiry Framework	Basic Science Process Skills					
Teaching	Observing	Communicating	Classifying	Measuring	Inferring	Predicting
Instructional Management	-.283	.075	-.384*	.026	-.026	-.175
Building Understanding	-.153	-.042	-.322	-.132	-.040	-.250
Direct Instruction	-.221	.102	-.327	.025	-.028	-.119
Social						
Emotional Expression	-.153	.050	-.403*	-.026	.085	-.154
Open Communication	-.224	.035	-.472*	-.029	.017	-.136
Group Cohesion	-.352	-.039	-.576**	-.038	.198	-.043
Cognitive						
Triggering Event	-.245	-.031	-.332	-.100	-.015	-.203
Exploration	-.348	-.007	-.547**	.020	.081	-.093
Integration	-.182	.188	-.404*	.131	.082	-.085
Resolution	-.304	-.146	-.340	-.062	-.147	-.312

While the rest of the BSPS are not significantly related to the COI framework, this only implies that students who just rely on the limited resources would not seek for additional data, learning scope is constrained, and distance learning process in line with the COI framework became insufficient. According to a DepEd memorandum DM-CI-2020-00162, a minimum of 2 hours daily are given to Grade 7. With this kind of platform, students had a limited time to make online classes effective and worthy though lessons are not totally discussed the way it must be. Lowenthal (2016) also found on his study that teachers gave importance on spending time with own strategy of social presence like greetings, empathy, salutations but then shifted quickly to teaching presence behavior such as dealing with lesson proper, mostly likely because of time limits.

All sub-variables under social presence is significantly related to classifying. Wei and Chen (2012) also found that social presence influenced students' learning interaction during online class and the students feel comfortable only once it is achieved. For this, Drouin and Vartanian (2010) suggest teachers design learning environments with SOC in mind to increase learning, satisfaction, and retention.

Under cognitive presence, only exploration and integration variables are significantly related to classifying. This indicates that exploring more of what have been told by the teacher was very significant even not during the synchronous class. Seeking solutions to a certain problems became so apparent to the learners, brainstorming and asking different questions as well as bringing opinion during online class was achieved. A fast paced of pre and post-test greatly affect the students gained scores. Although DeNoyelles et al. (2014) revealed that online discussions beyond the exploration phase rarely show the level of cognitive presence, Gorksy and Blau (2009) found social presence not related with students' cognitive performance rather cognitive presence correlates with subject matter in terms of difficulty. Various learning styles must be incorporated during synchronous class, not all were visual learners, some are auditory, some needs to undergo remediation program on areas such as reading and writing (Panoy et al., 2022). Online classes were hard to achieve successfully if these learners were not honed and molded holistically.

Table 6

Difference between the PRE and POST scores of the respondents in Basic Process Skills

Basic Science Process Skills	Pre-Test		Post-Test		Mean Difference	t	df	Sig. (2-tailed)
	Mean	SD	Mean	SD				
Observing	7.50	2.77	6.39	2.99	-1.107	-2.12	27	.054
Communicating	3.36	2.63	3.68	3.01	.321	.648	27	.523
Classifying	4.32	3.07	6.32	2.78	2.000	3.535	27	.001
Measuring	3.11	3.14	4.71	3.41	1.607	3.324	27	.003
Inferring	5.50	3.13	5.39	3.01	-.107	-.165	27	.871
Predicting	6.29	2.93	5.61	2.35	-.679	-1.30	27	.205

Table 6 shows that significant differences exist between the pre-test and post-test results of classifying and measuring among the six BSPS. This explains that respondents who participated in synchronous classes noticeably had interest in comparing things, looking at the similarities and

differences and categorizing things according to its characteristics and properties. Likewise, respondents under the skill of measuring were highlighted, computation were the focus, formulas were used, lessons were explained well and profoundly. Both skills resulted on a way that online classes must be done accordingly, with proper delivery and continuous flow of the lesson.

The COI framework played a big part on the synchronous classes in trying to find out the current status of the respondents in terms of their basic science process skills. Unfortunately, only classifying and measuring made a significant difference, while the other skills resulted to be imprecise. A lot of reasons can be made from this occurrence such as insufficient time given to each major subjects, students from this group are not serious when they were inside the classroom, incorporation of strong and strict rules, giving of additional activities, providing more video lessons and giving all students ample time to think, express, and participate.

5. Conclusion

This study found a significant relationship between the three presences of the CoI Framework and the BSPS as to classifying. Likewise, there is a significant difference between the pretest and posttest scores of the respondents in basic science process skills as to classifying and measuring.

Teaching presence during synchronous class is very important as it helps the students to experience quality education. In line with this, teacher facilitation, clear communication and instructions, timely feedback, and effective reinforcement must be emphasized. Cognitive presence which highlights the intense discussion, insightful and engaging interaction among the students virtually could help them construct meaning through continuous communication. Students must be given enough time learning different concepts, formulas, science vocabulary and reading scientific text. As Basic Science Process Skills need to be achieved in science education, utilization of open ended questions and activities is a way to enhance student's skills in the long run. Adapt think-pair-share during synchronous classes as well as providing a lot of learning activities over assignments will encourage more discussions and comprehensions. In addition, enabling breakout rooms during group activities is highly suggested as it offers a wide variety of interactions among students. Simple and safe laboratory experiment that could be done at home is advisable so that students could continue with inferring and predicting skills development.

Motivate students by letting them communicate through different illustrations, drawings, and figures.

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Infographic Material as Supplementary Learning Tool in Advancing Scientific Knowledge of Modular Distance Learners

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Abstract

The study utilized descriptive-developmental research design through the use of integrated, adapted, and expert-validated survey questionnaires, pretest and posttest to find the effects of self-designed problem-based infographic material as supplementary learning tool in advancing the scientific knowledge of thirty (30) Grade 7 students in a public high school in San Pablo City. Modular distance learning related factors and the preferred multimedia resources of the respondents were obtained. Results showed that the problem-based learning stages – problem comprehension, curriculum exploring, and problem solving, and the infographic design elements – visual, content, and knowledge elements, were highly integrated in the developed infographic material. As to the overall acceptability of the problem-based infographic material, intellectual, life skills, and affective development were perceived to be acceptable. Scores of the respondents as to the scientific knowledge – content knowledge, procedural knowledge, and epistemic knowledge, were found to have increased after utilizing the material. Statistical tests of difference also reflected significantly on the scientific knowledge of the learners implying that the use of problem-based infographic material has improved the skills of the learners while no significant relationship to the intellectual, life skills, and affective development. This concludes that the acceptability of the problem-based infographic material partially affects the scientific knowledge of the students.

Keywords: *Problem-based learning, Infographic, Scientific knowledge, Modular distance learning*

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1. Introduction

A billion and a half pupils in 188 countries/economies is unable to attend school in 2020 due to the pandemic (OECD, 2021). Students across the world have experienced schools that are open one day and closed the next, creating significant interruption in their education. Many education systems are currently struggling as the pandemic continues, and the situation is continuously changing. As the Philippines struggled with the impact on communities (Simbulan, 2020), the education sector had to conform to the new scenario, which prohibits face-to-face interaction and mass meetings.

Various distance learning modalities were adapted like online distance learning, blended learning, and modular distance learning to cope with various needs of every student in the Philippines. Due to these changes, students have difficulty in expressing their scientific abilities and skills through the learning materials distributed to them, and the addition of learner's task sheets submitted weekly. For instance, the Mean Percentage Score (MPS) in Science of Grade 7 students of San Vicente Integrated High School obtained during pre-pandemic period were 64.08% for S.Y. 2017-2018, 67.22% for S.Y. 2018-2019, and 75.89% for S.Y. 2019-2020. However, for S.Y. 2020-2021 the MPS of Grade 7 Science dropped to 68.75%. This was obtained at the height of pandemic where distance learning is implemented.

To address this issue, countless reminders, constant monitoring of the advisers and subject teachers through phone calls, text messages, chats, were administered but still the response of some learners and even their parents have been minimal and the results of their scores were poor. It is in this premise that this study devised a way to deliver instructions to learners in the modular distance learning modality through comprehensive and contextual real-life scenarios simplified in a form of infographic.

From the study of Siricharoen and Siricharoen (2015), infographics were employed to support data visualization when there was little time and too much information to understand. Since science education focuses on improving students' scientific literacy, preparing them to be rational and active citizens capable of making decisions and judgements about the application of scientific knowledge that may have health, environmental, or societal consequences (Basco, 2020) is necessary. In this way, students' performance may be further developed by utilizing creative materials like infographics. Hence, this study evaluated the developed infographic material.

2. Literature review

2.2 Problem-based Learning

Problem-based learning (PBL) is founded on a Constructivist Approach and hence encourages active learning. Students participate in activities in groups, usually in a tutorial or seminar setting. Self-directed learning, effective problem solving, communication, and cooperation abilities are all cultivated through PBL (Edith Cowan University, n.d.). According to Overton (2016), PBL can be considered subcategory of context-based learning. It presents real-life contexts in a form of problem scenarios. The fact that the issues or scenarios are met before all of the essential learning has taken place and function as the catalyst for fresh learning is a key element of PBL. As a result, it differs from problem solving, in which challenges are typically faced after learning has occurred. Moreover, it has a very well-defined framework that must be adhered to in order for it to be effective. This method can be altered for any subject and grade level, but to complete a PBL experience, the steps must be done in order.

In the PBL approach, the problem is provided first than teaching relevant content so that students apply their knowledge to solve challenges. The PBL assignments can be simple or complex, and might last a whole semester. Any school topic, from social studies and literature to mathematics and science, can benefit from PBL. An effective PBL strategy should include qualities such that students are challenged to understand things in the classroom on a deeper level. Students are being pushed to make judgments that they can defend connecting current course objectives to past courses and expertise in a clear and concise manner. As the students work together to solve the challenging problem, they engaged in a multi-stage process to answer an open-ended challenge.

Silva (2018) found PBL teaching technique as beneficial to student learning because it encourages the integration of theory and practice, which increases motivation to learn. This is supported by Chamsai and Chanchusakun (2020) providing evidence that students' learning achievements were higher after PBL with infographics than before problem-based learning without infographics. The mathematical abilities of the students have increased after utilizing infographics.

2.3 Infographics

Infographics are visual representations of data in a condensed space and an artistic fashion. They are able to convey information swiftly that keep readers interested in what they are reading. They provide crucial data and information while being fun to read and comprehend (Siricharoen & Siricharoen, 2015). According to Siricharoen and Vinh (2016), infographic is a visual representation of information, facts, or expertise that can be created using a variety of software; some are easier to use than others. A variety of websites can be used to visualize data.

In recent years, infographics have become increasingly popular as a means of visually presenting data. It is a style of visualization that tries to provide any content with a visual composition for the target audience, mixing components such as shapes, symbols, images, photographs, illustrations, and words (Ozdamli & Ozdal, 2017). In teaching and learning, educators can use professional insights to teach students about the characteristics of good infographics (Gallicano et al., 2014). Overall characteristics of simplicity, visual storytelling, accurate and ethical data presentation (by not glossing over contextual factors that can influence the audience's conclusions), source citation, and the application of design principles are all features of a good infographic.

In light of the purposes and benefits of infographics as well as the characteristics of today's students, Alrwele (2017) believes that infographics can be used to help students understand the information presented in a particular course, and that it would be worthwhile to investigate students' perceptions of infographics as a teaching and learning tool. The cores of infographics include visual elements, content elements, and knowledge. Relevant to this, Siricharoen and Vinh (2016) constructed an infographic evaluation-questions matrix according to dimensions of evaluation such ash data, sources, story and flow, design style, color and size, icons, diagrams and charts, words, and publisher. These dimensions of evaluation were classified into the three foundation of infographics which are visual and content elements, and knowledge.

Basco (2020) found that infographics were significant in terms of improving academic performance in Science among learners. Infographics paradigm was created to better comprehend the potential of infographics in the teaching and learning process. This includes the aspect in a learner to be developed in terms of life skills development, intellectual development, affective development.

2.3 Scientific Knowledge

Scientific literacy refers to a person's ability to ask, find, or determine answers to inquiries regarding everyday experiences that arise from curiosity. For Jufrida (2019), scientific literacy is the capacity that pupils must possess in order to understand science, analyze and apply scientific concepts to real-world problems. It is critical for students to understand what they study in school and has a significant impact on their cognitive capacities.

The Organization for Economic Cooperation and Development (OECD) through the Programme for International Student Assessment (PISA) organizes international studies on learners' science literacy skills. In this context, scientific literacy is regarded as a critical component of education for all students, regardless of whether or not they intend to pursue science further (Turiman et al., 2012; OECD, 2013). Based on the PISA Assessment and Analytical Framework (2018), the term "scientific literacy" refers to both a state of mind and a body of knowledge of science and technology. Science and technology, on the other hand, have different aims, techniques, and products. Technology looks for the best solution to a human problem, and there may be multiple best solutions. Science, on the other hand, seeks the truth. a response to a specific question regarding the natural material world. Gormally (2012) classified scientific literacy into categories such as understanding methods of inquiry that lead to scientific knowledge, and organizing, analyzing, and interpreting quantitative data and scientific information. These categories have been subdivided into various skills which were used to test the scientific literacy of their respondents.

According to Siarova (2019), scientific literacy goes beyond the mere knowledge of scientific content. It should be understood as the ability to engage critically with and make informed decisions about science-related issues. This broader approach to scientific literacy should be coherently integrated in curricula. Critical thinking and active engagement should be emphasized as important learning outcomes along with fundamental literacy, scientific knowledge and competences and a contextual understanding of science.

Research highlights the need to integrate various elements of scientific literacy across educational levels and subject areas (such as science, history, geography, citizenship, health, and media education). Fostering scientific literacy requires an integrated approach involving investment in, and re-thinking of, both formal and non-formal education. Measuring scientific

literacy comprehensively proves to be a challenge. Existing tools are often focused on students' level of scientific knowledge and competences, leaving aside such elements as critical thinking and active engagement. The development of comprehensive assessment instruments could allow grasping scientific literacy more holistically and better understanding what educational approaches can help develop it.

2.4 Theoretical Framework

This study is anchored on Cognitive Theory on Multimedia Learning (Mayer, 2014). This theory specifies five cognitive processes: selecting relevant words from the presented text or narration, selecting relevant images from the presented graphics, organizing the selected words into a coherent verbal representation, organizing selected images into a coherent pictorial representation, and integrating the pictorial and verbal representations and prior knowledge.

For Quarter 3 of Science 7, it discusses Force and Motion, specifically on the topics of Sound, Light, and Heat (K to 12 Curriculum Guide for Science, 2016). These competencies were used for the PBL Integration which according to the National Education Ministry of Indonesia as cited by Wicaksono (2019) has been found to be capable of developing science process skills of the learners as a strategy in face to face learning.

The multimedia preferences of the learners were considered in the development of an instructional material based on the findings of Gueta and Janer (2021) that the most helpful tools for learning are the educational technology used in schools, and students' preferences in using various multimedia tools. Similarly, the factors affecting modular distance learning were also identified. Some of the modular distance related factors were based on the Modified Learner Enrolment and Survey Form (2021) as to household capacity and access to distance learning. Similarly, Drăghicescu (2014) suggests that PBL involves three stages which include problem comprehension, curriculum exploring, and problem solving. When a teacher uses PBL in the classroom, he takes on the role of coach for his pupils, guiding them through the research process and capturing their interest in authentic and relevant learning.

In the development of the infographic learning material, the study considered Siricharoen and Siricharoen (2015) on three essential factors: visual, content and knowledge elements. This is on top of the findings of Siricharoen and Vinh (2016) that a highly valid PBL infographic learning material contains generally acceptable infographic design integration and problem-based learning stages integration.

As concluded by Basco (2020), the use of infographics in the teaching-learning process has been effective. Thus, it was suggested for utilization in science classes to enhance students' academic performance through intellectual development, life skills development and affective development. In addition, this study considers the PISA Draft Science Framework (2015) on the importance of scientific knowledge in learning the concepts of science prior to its application in skills. Thus, all three types of scientific knowledge are required for scientific literacy which are content knowledge, procedural knowledge and epistemic knowledge.

With these premises, this study applied all the principles in the development of the PBL through a researcher-made infographic material in modular distance learning. As the PBL has been proven to be an effective teaching strategy, it has not been incorporated in creating an infographic instructional material. Thus, this study fills this research gap.

3. Methodology

3.1 Research Design

The research employed a quantitative method that includes the descriptive and developmental designs by means of developing a problem-based infographic material and pre and post-test to check the effectiveness of the material in the teaching-learning process. Developmental research follows a systematic design through development and evaluation of instructional programs or materials, and evaluating changes over an extended period of time. On the other hand, descriptive design is a type of study in which data is gathered qualitatively and examined using quantitative methods. Surveys, interviews, correlation studies, observation studies, and content analysis are all used to collect data.

3.2 Participants of the Study

The participants of the study are thirty (30) randomly chosen Grade 7 students of a public high school in the San Pablo City, Laguna. Another set of participants include nine (9) experts who validated the infographic material.

3.3 Research Instrument

The study administered five (5) adapted survey questionnaires, teacher-made problem-based infographic material, and teacher-made pre-test and post-test questionnaires for scientific

knowledge assessment. A survey questionnaire assessed the factors relating to modular distance learning as to household conditions that may impact the learners in terms of capacity, assistance to learners, gadgets available, internet access, connectivity sources, and learning challenges. The survey was adapted from Gueta and Janer (2021) and the Modified Learner Enrolment and Survey Form (2021). Multiple responses were required to some of the questions under this survey.

Another survey questionnaire in profiling the learners as to their multimedia preferences was adapted from Nicholas (2020) related to the various learning tools helpful for Generation Z learners, various teaching aids and preferred learning materials. Because they can provide a higher degree of dispersion and decrease neutral responses, 4-point Likert scales were employed to gauge the level of preference from highly preferred to not preferred (4 – highly preferred; 3 – preferred; 2 – seldom preferred; 1 – not preferred).

A survey questionnaire on the integration of the learning stages of PBL in the developed infographic material for the selected topics in Science 7 was also utilized. The survey was patterned from Drăghicescu (2014) with 14 statements generated to identify the integration of learning stages of PBL in terms of problem comprehension, curriculum exploring, and problem solving. Additionally, a survey questionnaire on the extent of integration of the infographic design elements to the developed PBL infographic material was utilized. This questionnaire was patterned from Siricharoen and Vinh (2016) with 41 statements to identify the incorporation of infographic design elements in terms of visual elements, content elements, and knowledge elements. A 4-point Likert scale was also employed to provide higher degree of dispersion and decrease neutral responses ranging from highly integrated to not integrated (4 – highly integrated; 3 – moderately integrated; 2 – slightly integrated; 1 – not integrated).

Lastly, a survey questionnaire for the student-respondents on their overall acceptability of the use of the PBL infographic material was utilized. The survey was adapted from Basco (2020) with 15 statements classified under the life skills, affective, and intellectual development of the learners upon utilizing the said infographic material. A 4-point Likert scales were also employed to gauge the level of acceptability from highly accepted to not acceptable (4 – highly acceptable; 3 – moderately acceptable; 2 – slightly acceptable; 1 – not acceptable).

A multiple-choice pre-test and post-test were used to measure the levels of scientific knowledge of the students in terms of content knowledge, procedural knowledge and epistemic

knowledge. The test was adopted from the PISA 2015 Framework. A table of specifications was made to show the distribution of question items in both tests.

Prior to the actual data gathering, the instruments were subjected to external and internal validation to ensure validity and reliability. As to the scientific knowledge test, a reliability test during the pilot study was conducted to identify its level of reliability.

3.3 Research Procedure

Upon approval from concerned individuals and offices, a consent form was disseminated to the students and parents before handing out the survey questionnaires on Modular Distance Related Factors and Multimedia Preference, and the conduct of Pre-Test. The coverage of the utilization of the problem-based infographic material were three consecutive weeks with topics such as Sound, Light, and Heat based on the Budget of Work (BOW). After the 3-week period, the post-test was administered to assess the impact of the use of problem-based infographic material to the respondents' scientific knowledge. Likewise, a survey questionnaire was given.

3.4 Statistical Treatment of Data

The study used both descriptive and inferential statistics. Descriptive measures such as mean and standard deviation were applied to describe the perception of the respondents as to the material and performance of the respondents in terms of their scientific knowledge. For the inferential statistics, Pearson Moment Product Correlation was utilized to find significant relationship among variables. Paired t-test was employed to determine if there is a significant difference between the pre-test and post-test scores of the students as exposed to problem-based infographic material. All inferential statistics were tested at 5% level of confidence.

4. Findings and Discussion

Table 1 shows the summary of the expert respondents' perception on the extent of integration of the problem-based learning stages. Generally, the stages of problem-based learning were incorporated and is highly integrated except for problem solving being moderately integrated (M = 3.49, SD = 0.51), with an overall mean value of 3.62 (SD = 0.43) which is highly integrated.

Table 1

Extent of Integration of the Stages of Problem-Based Learning

Stages	Mean	Standard Deviation	Verbal Interpretation
Problem Comprehension	3.73	0.33	Highly Integrated
Curriculum Exploring	3.63	0.51	Highly Integrated
Problem Solving	3.49	0.51	Moderately Integrated
Overall	**3.62**	**0.43**	**Highly Integrated**

Legend: 3.50-4.00 Highly Integrated (HI); 2.50-3.49 Moderately Integrated (MI); 1.50-2.49 Slightly Integrated (SI); 1.00-1.49 Not Integrated (NI)

Table 2 summarizes the extent of the integration of visual elements in terms of design style, color and size, icons, and diagrams and charts. An overall high integration level (M = 3.61, SD = 0.36) was evident in all visual elements except for diagrams and charts being moderately integrated (M =3.33, SD = 0.50).

Table 2

Extent of Integration of Infographic Design Visual Elements

Elements	**Mean**	**Standard Deviation**	**Verbal Interpretation**
Design Style	3.75	0.33	Highly Integrated
Color and Size	3.69	0.43	Highly Integrated
Icons	3.67	0.50	Highly Integrated
Diagrams and Charts	3.33	0.50	Moderately Integrated
Visual Elements	**3.61**	**0.36**	**Highly Integrated**

Legend: 3.50-4.00 Highly Integrated (HI); 2.50-3.49 Moderately Integrated (MI); 1.50-2.49 Slightly Integrated (SI); 1.00-1.49 Not Integrated (NI)

The result suggests the importance to focus on the content so that the infographic material will be of great help for learners to understand the topic easily. In addition, color and size and the icons to be used in creating a learning material like infographic should also be considered so that the material can attract the readers and serve its purpose to where it is intended. Utilizing diagrams and charts should also be considered to offer an exceptional learning material for the students. The use of this visual element may present data in a comprehensible manner that will easily help the students identify information. Infographics are made up of a variety of visual elements with

different looks, such as icons, photos, decorations, and text. Graphic designers who are skilled at what they do usually execute it with an aesthetic and creative mindset, infusing them with personality and style (Lu, 2020). Several activities must be taken during the construction of infographics' visual content in order to maximize the efficiency of the visualization process.

Table 3

Extent of Integration of Infographic Design Content Elements

Elements	Mean	Standard Deviation	Verbal Interpretation
Data	3.87	0.28	Highly Integrated
Story and flow	3.67	0.33	Highly Integrated
Words	3.78	0.34	Highly Integrated
Content Elements	**3.77**	**0.30**	**Highly Integrated**

Legend: 3.50-4.00 Highly Integrated (HI); 2.50-3.49 Moderately Integrated (MI); 1.50-2.49 Slightly Integrated (SI); 1.00-1.49 Not Integrated (NI)

Table 3 summarizes the extent of integration of infographic design elements in the developed infographic material as to content elements. All elements were highly integrated with a mean value of 3.77 (SD = 0.30). Data, story and flow, and words were evidently incorporated in the developed infographic material.

The items included in the infographic were focused on the inclusion of facts, statistics, texts, references, time frames, and others. Considering these elements to produce quality infographic material may result to an effective learning material which can later on be utilized by learners and can cover other topics of other subject areas. Similar to the findings of Parveen and Husain (2021), students are more likely to read the facts, understand the data, and draw conclusions more quickly and thoroughly when they are motivated to do so.

Table 4 summarizes the extent of integration of infographic design elements in the developed infographic material as to knowledge element. Both indicators, sources and publishers, were highly integrated in the material (M = 3.69, SD = 0.39).

Table 4

Extent of Integration of Infographic Design Knowledge Elements

Element	Mean	Standard Deviation	Verbal Interpretation
Sources	3.83	0.22	Highly Integrated
Publishers	3.56	0.57	Highly Integrated
Knowledge Element	**3.69**	**0.39**	**Highly Integrated**

Legend: 3.50-4.00 Highly Integrated (HI); 2.50-3.49 Moderately Integrated (MI); 1.50-2.49 Slightly Integrated (SI); 1.00-1.49 Not Integrated (NI)

The information gathered to create the infographic material came from reliable sources in order to provide factual and quality content. It is very important to identify sources that are reliable in order to harvest data that is factual since it will be incorporated as a tool for learning. People this age actively choose, accept, and share information, and that personal judgment played a significant role in this process (Won, 2018).

Table 5

Acceptability of the PBL Infographic Material

Elements	Mean	Standard Deviation	Verbal Interpretation
Intellectual Development	3.38	0.44	Moderately Acceptable
Life Skills Development	3.41	0.52	Moderately Acceptable
Affective Development	3.43	0.50	Moderately Acceptable
Overall Acceptability	**3.41**	**0.43**	**Moderately Acceptable**

Legend: 3.50-4.00 Highly Acceptable (HA); 2.50-3.49 Moderately Acceptable (MA); 1.50-2.49 Slightly Acceptable (SA); 1.00-1.49 Not Acceptable (NA)

Table 5 summarizes the student respondents' perception on the overall acceptability of the developed problem-based infographic material as to the skills they need to develop. Generally, all skills presented obtained moderately acceptable level (M = 3.41, SD = 0.43). It is evident that the affective aspect of the learner was developed (M = 3.43, SD = 0.50) since it provided opportunities for learners to engage into learning without them getting bored and enhance their ability to be creative. Intellectual development (M = 3.38, SD = 0.44) and life skills development (M = 3.41, SD = 0.52) were also an important aspect to be enhanced to achieve holistic education. Not only

it will advance the cognitive abilities of the learner but also through the help of infographics, it will increase their creativity and fact-finding abilities.

Infographics can be considered alternative educational tools that may provide solutions for educators who teach abstract or complicated subjects that are difficult to express verbally. The findings support the claims of Alrwele (2017) that infographics may offer significant educational potential for improving learners' life skills, intellectual, and affective qualities. Similarly, it has been found to be beneficial in improving student achievement in learning lectures and courses.

Table 6

Test of Difference in the Level of Scientific Knowledge Before and After the Use of PBL Infographic Material

	Pretest		Posttest		t	df	Sig. (2-tailed)	Interpretation
	M	SD	M	SD				
Content Knowledge	6.467	3.3398	7.93	3.423	- 4.253	29	0.000	Significant
Procedural Knowledge	4.967	2.5118	6.73	2.677	- 4.851	29	0.000	Significant
Epistemic Knowledge	4.000	2.2438	5.67	2.695	- 3.953	29	0.000	Significant
Total Score	15.500	6.7607	20.33	7.284	- 7.293	29	0.000	Significant

Legend: Sig. (2 – tailed) > 0.05, Not Significant
Sig. (2 – tailed) < 0.05, Significant

Table 6 presents the test of difference in the level of scientific knowledge of the students before and after the use of the PBL infographic material. It can be observed that there is a significant difference between the pretest and posttest results of the respondents and their level of scientific knowledge as to content knowledge, procedural knowledge, and epistemic knowledge. For each topic, it consisted of 15-items questions, and for every 5 questions it measures the content, procedural, and epistemic knowledge of the learners.

These findings imply that after using the problem-based infographic material, the students were able to enhance their content knowledge, procedural knowledge, and epistemic knowledge. As a result, it was presumed that students have a basic understanding of the major scientific explanatory concepts and ideas that were included in the material distributed to them. In terms of measuring procedural knowledge, the test items were focused on understanding of techniques used by scientists to arrive at scientific conclusions. Lastly, it is evident that the epistemic knowledge of the students was enhanced. Test items were focused on grasping of justification for typical

scientific inquiry procedures, the status of assertions created, and the meaning of key words like theory, hypothesis, and data. It involved the analysis regarding various scientific concepts and theory like the occurrence of explosion in space, will there be sound produced, and others.

Table 7

Relationship between the Acceptability of the PBL Infographic Material and Level of Scientific Knowledge

Perceived acceptability	Level of Scientific Knowledge			
	Posttest			
	Total	Content	Procedural	Epistemic
Intellectual	0.037	-0.172	-0.026	0.344
Life skill	0.121	0.003	0.066	0.259
Affective	-0.050	-0.196	-0.150	0.262
Overall Acceptability	**0.043**	**-0.134**	**-0.040**	**0.326**

Table 7 shows the test of relationship between the perceived level of acceptability of the PBL infographic material and the posttest scores of the respondents as to their level of scientific knowledge. It can be observed that there is a positive correlation between the content knowledge and procedural knowledge when it comes to the life skill development of the learners. This means that as the level of scientific knowledge of the learners increases after using the problem-based infographic material, the life skill development also increases.

In terms of the epistemic knowledge, it obtained a positive correlation in all skills developed – intellectual, life skills, and affective. This means that the learners can justify typical scientific inquiry procedures, identify and give meaning to key words presented in theory, hypothesis, and data. However, there are negative correlation values obtained in content knowledge and procedural knowledge in terms of the intellectual and affective development of the learners. A negative correlation value implies that the variables move in opposite direction.

This is in contrast to the study of Basco (2020) that infographics had a considerable impact on students' intellectual development. In terms of the development of life skills, infographics strengthen the cognitive domain and help people develop life skills like communication and teamwork. In order to effectively relate and work with people in the twenty-first century learning environment, several abilities are required. Lastly, in terms of affective development, it indicates that infographics should be used in class to increase motivation and self-confidence.

5. Conclusion

The study sought to develop a problem-based infographic material to enhance the scientific knowledge of Grade 7 modular distance learners during the School Year 2021-2022. The study used descriptive-developmental research design focused on experts' perception on the integration of problem-based learning stages and infographic design elements and the students' perception on the overall acceptability of the infographic material to advance their scientific knowledge.

From the data gathered and interpreted, expert respondents perceived that the PBL learning stages and the infographic design elements were highly integrated in the developed problem-based infographic material. In addition, the students found that the intellectual, life skills, and affective aspects of the infographic material were moderately acceptable. Furthermore, there was an increase in the posttest scores compared to the pretest scores after utilizing the PBL infographic material. There was a significant difference on the level of scientific knowledge of the students before and after using the developed PBL material. Significant relationships were found in the epistemic knowledge and the acceptability of the infographic material as to intellectual, life skills, and affective development. However, a not significant relationship was found between content and procedural knowledge and the intellectual and affective aspect of the acceptability of the material. Therefore, there is no significant relationship in the overall acceptability of the problem-based infographic material and the level of scientific knowledge of the respondents.

Based on the findings of the study, it is concluded that the use of an infographic material increases the level of scientific knowledge of the students given that all elements were fully and highly integrated to create a quality learning material. It is effective in developing the said skills for the learners.

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Integrating Android-Based Applications in Teaching Chemistry for Improved Experiential Learning

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Abstract

With the unfavorable learning environment blamed for students' subpar Science performance, new approaches to education were developed including the advancing technology and its application in the educational process. This study intended to determine the effectiveness of integrating Android-based applications in teaching chemistry for improved experiential learning of students. The study used a descriptive-experimental design using one hundred twenty (120) junior high school students enrolled in one public high school in Alaminos, Laguna, for the school year 2021-2022. The study revealed a significant difference in the pre-test and post-test scores of the students based on experiential learning constructs. Likewise, a significant relationship was found among variables suggesting that student perceived the integration of Android-based application as effective tool in teaching chemistry. The study's findings indicate that the level of experiential learning of most students in Science improved after integrating the Android-based applications. Results suggest that teachers may consider using Android-based applications in teaching Science that includes learning activities suited to the topic and can give students the opportunities to improve the level of their experiential learning. Lastly, a study using low and high-performing students may be conducted to further assess the strength of the Android Applications as to applicability and effectiveness.

Keywords: *Android-based applications, experiential learning, junior high school*

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1. Introduction

Students are increasingly required to use their mobile devices (smartphones) for everything, hold the world in their hands, and access any information from any location. This eliminates the need to search for the data in the library. Consequently, a smartphone can be used for various purposes as mobile applications facilitate the accessibility of information. Each mobile application has a distinctive service-providing feature. It has resulted to using e-learning as an alternative approach to education and learning (Jin & Junio-Sabio, 2018). This method reflects the attributes of non-contact, representing the least risky strategy for avoiding the spread of COVID-19 (Madimabe & Omodan, 2021). In the never-ending education process in the 21st century, the emphasis has shifted to e-learning.

Things like social media contain elements of the web that communicate information exchange and are favorites among school-aged adolescents regarding how they interact and share information from every corner of the globe (Madimabe & Omodan, 2021). With smartphones and various feature-oriented applications, students can learn independently and take time to comprehend concepts, as everything is accessible with a single click. Specialists in educational research develop new methods for disseminating knowledge to the general public and then share the benefits of best practices with teachers and the broader community (Aliazas & Chua, 2021). This includes, among other things, introducing students to activities that will help them learn in innovative and creative ways. Students would be compelled to prioritize subject-specific instruction, urgently required (Panoy et al., 2022).

According to Sevari (2012), smartphones are inexpensive, and many users can own at least one smartphone per user. Researchers also claim that people enjoy using their smartphones since they are simple to use and can be carried around in their pockets at all times. According to Mansour (2015), smartphones are becoming increasingly significant in today's society because of their ability to connect. It is not only used for making phone calls and sending text messages, but it may also assist us in connecting with other forms of connectivity, such as social networking sites like Facebook, Twitter, Instagram and E-mail, among others (Villon & Del Rosario, 2022).

Alson (2016) indicates that smartphones connect users to social media, while some use them as tool for learning; they use them as a calculator, write notes, search for Google and so on. Some use their smartphones as a tool for social networking. Users can download an application to

get the latest song or movie, which is convenient for those who lead a busy life. It can also provide the latest in entertainment (Callo & Baguna, 2017). These emphasize a change in the reading habits of the general public. In direct proportion to the average use and number of mobile device users, the increase in knowledge generated due to scientific and technological advances is directly proportional. By the year 2015, students at 88 percent between the ages of 13 and 17 have used smartphones; therefore, school administration should reconsider their smartphone ban policy so that smartphones are appropriate in today's learning environments (Clayton and Murphy, 2016).

The use of a mobile application like High School Chemistry Class, an application with tons of different science experiments with instructions students can do right at home easily. Likewise, Periodic Table-Game android applications can help students learn the periodic table and can allow them to memorize the symbols and other properties of chemical elements quickly. The Android Application used in the study, namely; Chemi Lab-Interactive Chemistry Learning (Davenport et al., 2012), is a 3D interactive application for learning fundamental Chemistry concepts. Elements & Periodic Table Quiz (Setu & Basar, 2019) this application, students can learn the names and symbols of all 118 chemical elements of the Periodic Table (Astiningsih & Partana, 2020) with this application. IN MEL VR Science Simulations (Sharpe et al., 2008), students can explore chemical elements, atoms and molecules in Virtual Reality (Naik, 2017).

These applications helped improve students' experiential learning by providing activities and opportunities to learn independently. Since students during the Covid-19 pandemic were forced to continue their studies at home without the guidance of their teachers, it was hard for them to understand their lessons fully (Panergayo & Aliazas, 2021). Hence, these applications were introduced to the Grade 8 students of Alaminos Integrated National High School that were used as instructional material in learning Science. These served as their mentors and facilitators in learning. Students' experiential learning improved by conducting experiments provided by the Applications, playing games, exploring chemical elements in Virtual Reality and many more.

2. Literature Review

2.1. Android-based Application Integration to Teaching

According to Kacetl and Klímová (2019), mobile learning is becoming a significant component of education because it offers excellent opportunities for learning a foreign language. In a study by Yang et al. (2013), a quasi-experiment was conducted in an elementary school with

92 sixth graders to evaluate the efficacy of the suggested approach. The experimental findings demonstrate that, in terms of learning outcomes, the concept map-oriented ubiquitous learning strategy is much more beneficial to students when they read printed books than traditional book reading and the conventional universal learning approach. Likewise, the study of Panergayo and Aliazas (2021) suggested that there is a strong acceptance among students that technology adoption is necessary during the time of health crisis.

A study by Jin and Junio-Sabio (2018) looked into the potential use of mobile devices in a few Manila, Philippines, public senior high schools. In this study, 152 students from various schools participated as respondents. It was discovered that most participants used mobile devices and had internet connections when engaging in learning activities outside of traditional classroom settings. As technology adoption has been increasing among students, flexible learning modality was also represented by these changes in the learning environment (Callo & Yazon, 2020).

In another study, Ramos and Comendador (2019) created the mobile app ARTitser as a learning aid for Biological Science. The iOS above application, which uses augmented reality (AR) technology, can assist teachers in facilitating the delivery of regular lectures by providing a realistic portrayal of objects for a better study experience. It can also help teachers monitor students' performance using an interactive and ever-changing AR lesson. Similarly, an application of the binary ionic bonding subject in chemistry is developed in a research study by Bactong et al. (2021). The respondents concurred that the application had improved their focus on learning in terms of their intrinsic drive.

The qualities and opportunities of using smartphones for students are explained in the study of Mulyani et al. (2019), particularly concerning a smartphone offering experiential learning activities. The study aims to identify the benefits, difficulties, and solutions of using mobile phone applications in teaching and learning. The study concludes that students are enthusiastic about using smartphones for social networking, instant messaging, playing online games, and other enjoyable activities. Smartphones have benefits, but if not used correctly, they can also be a distraction and a problem (Aliazas et al., 2021). Students may learn new information in experiential learning courses by participating in learning that takes place in real-life situations. Students can learn more about their questions and how to answer them by using mobile devices to make observations outside of the classroom (Petrovic et al., 2014). Farrah and Abu-Dawood (2018)

suggest that students could comprehend and learn more effectively when using mobile applications.

2.2. Experiential Learning

This research is based on the Experiential Learning Cycle, a popular learning framework popularized by David Kolb (2018). The experiential learning cycle consists of the four stages of learning—experience, reflection, thought, and action—which are repeated with each new interaction and experience. Experience-based learning is a cycle that begins with a new experience, continues through contemplation, analysis, and the development of new perspectives, and culminates in a decision to take action by actively experimenting with or testing one's newfound knowledge. Taking part in this cycle is so commonplace that it often goes unnoticed that it is a form of informal education. It's a constant and ongoing part of our lives, and it happens with surprisingly little effort on our part. People tend to favor certain approaches when using this research (Syaifullah et al., 2021).

The cognitive domain taxonomy developed by Bloom (Huitt, 2011) is another framework used to direct this investigation. K-12 educators, as well as their higher education counterparts and researchers, have relied on this framework for decades. There were six main parts to it: awareness, understanding, competence, critical thinking, and assessment. Following "knowledge," the categories presented were "skills and abilities," with the caveat that knowledge was required to perform these abilities (Wilzon, 2016).

According to experiential learning theory, knowledge and competence can be improved through repeated cycles of experience and reflection. With Bloom's taxonomy, progress is track through a progression of ever-more-in-depth and intricate stages of education. The two models are conceptually combined to demonstrate how students can progress to greater depths of knowledge through repeated exposure to practical situations (McCarthy, 2016).

The design of the android applications used in this study provides opportunities for the student to engage in some experiential learning activities that can help them develop cognitive learning, such as knowledge and comprehension analysis, and gives priority to evidence for lifelong learning (Carada et al., 2022). Using android applications, the study findings assist students in developing pleasant and productive study habits and thus, improve the learning process.

3. Methodology

A descriptive-experimental research design was used to determine the effectiveness of integrating Android-based applications in teaching Science 8 students in the school year 2021-2022. This is a process of collecting and analyzing numerical data. According to Creswell (2016), quantitative research contains and analyzes numerical data. It can also generalize results to a larger population, find averages and patterns, and test causal relationships and predictions.

The Android Applications used in the study were Chemi Lab-Interactive Chemistry Learning (Davenport et al., 2012), High School Chemistry Class (Astiningsih & Partana, 2020), Periodic Table-Game (Setu & Basar, 2019), MEL VR Science Simulations (Sharpe et al., 2008) and Elements and Periodic Table Quiz (Naik, 2017). These applications were used as the student's learning material in Science. These included activities where students can learn and improve their experiential learning through various activities and experiments.

One hundred twenty (120) 8^{th} grade students at Alaminos Integrated National High School who were enrolled during the school year 2021-2022 make up the heterogeneous samples of the study. A randomly generated technique was used to select 120 samples from among the high and low-performing groups of students. The sample size was calculated using Andrew Fisher's formula (Jung, 2014) with a confidence level of 95% and a confidence interval of 0.5%.

Students' perceptions of the features of the Android-based application in teaching science were assessed using a questionnaire created by the researcher. Likewise, their experiential learning was measured regarding their cognitive categories, such as knowledge, comprehension and skills. Three (3) sets of instruments were used in the study to gather the data necessary to answer the research questions.

Basic information about the respondents was gathered through a questionnaire created by the researcher. The questionnaire used to determine the factors related to the effectiveness of integrating an Android-based application in teaching Science includes 20-item statements. The instrument used to determine the students' experiential learning level comprised a 20-item self-made pre-test and post-test. The test was based on its objectives and included items that can assess both learnings of the concepts and cognitive categories in Science using Android Applications. Such tests were scrutinized and validated by a panel of experts from a national high school in Laguna. Some of the comments incorporated were changing the pre-test and post-test questions

from essay to multiple choice, attaching android legal notice on the use of android applications and changing some Android-based applications that can cater to students more experiential learning. Lesson exemplars (LE), curriculum guide, android applications, pre-test and post-test were used to determine the instructional material's effectiveness. These instruments were checked and validated by a panel of experts composed of two head teachers, one master teacher and two Teacher III from a national high school in Laguna to ensure the effectiveness of using android applications in improving the experiential learning of grade 8 students.

The following statistical tools were used to address the issue identified by the research. The mean and standard deviation were used to determine students' perception of Android Applications' features and their level of experiential learning before and after using Android Applications. A t-test was used to determine if there was a statistically significant difference in students' learning experiential learning before and after using the android applications and determine the relationship between students' learning experience in Science and the features of Android Applications.

4. Findings and Discussion

Table 1

Test of Difference in the Experiential Learning of Students Before and After Using the Android Applications as to Knowledge, Comprehension and Analysis.

	Pre-test		Post-Test		Mean Difference	t	df	Sig. (2-tailed)
	Mean	SD	Mean	SD				
Knowledge	5.49	2.520	8.53	1.869	3.042	12.877	119	.000
Comprehension	3.17	1.568	4.04	1.246	.875	4.690	119	.000
Analysis	1.50	1.174	2.79	1.425	1.292	8.038	119	.000
Overall	10.17	4.057	15.53	2.620	5.167	13.471	119	.000

Legend: If sig ≤ .05 (significant); if sig > .05 (not significant)

To test the effectiveness of Android-based applications as a learning material integrated with teaching Science and the improvement of the student's experiential learning, the Android-based applications, namely; Chemi Lab-Interactive Chemistry Learning (Davenport et al., 2012), High School Chemistry Class (Astiningsih & Partana, 2020), Periodic Table-Game (Setu & Basar, 2019), MEL VR Science Simulations (Sharpe et al., 2008) and Elements & Periodic Table Quiz (Naik, 2017) were used as a learning material of students in learning Science.

Students were given a pre-test before using the said Applications and a post-test after using the Android Applications. The results indicate that the experiential learning of students before and after using the android applications as to Knowledge, Comprehension and Analysis is significantly different. It can be gleaned from the table that knowledge has a t-value of 12.877 (p=.000), comprehension has 4.690 (p=.000), and analysis has 8.038 (p=.000) with an overall t-value of 13.471 (p=.000).

Experience-based learning, in which students learn through activities like field trips and research, can benefit significantly from integrating Android-based applications as supplementary course materials. Knowledge, comprehension, and analysis in junior high school students can all benefit from this kind of hands-on experience (Ortiz & Aliazas, 2021). The fact that students' mean gain scores went up suggests that using Android-based apps as a learning resource is productive and successful.

Android applications provide a fun way for students to engage in educational activities on their mobile devices. Mobile applications can facilitate experiential learning by opening up new channels for it (Panoy et al., 2022). Students can enhance their experiential learning through the Android-based applications' provided activities and experiments by applying what they've learned in real-world contexts. According to Garillos (2012), students' test scores improved dramatically between the pre-test and post-test when teachers used instructional materials. Furthermore, Voshaar et al. (2022) research on the impact of mobile app use on learning success in accounting education shows that dedicated app users outperform casual app users on final exams.

Table 2

Test of Correlation Between the Experiential Learning of Students in Science and the Level of Effectiveness of Android Applications in Teaching

	Experiential Learning		
	Knowledge	Comprehension	Analysis
User-friendliness	.546**	.472**	.533**
Effectiveness	.444**	.322**	.263**
Usability	.629**	.612**	.552**
Satisfaction	.604**	.523**	.653**

***Correlation is significant at the 0.01 level (2-tailed).*

The table presents the significant relationship between the experiential learning of students in Science and the level of effectiveness of integrating Android-based applications in teaching chemistry. The result shows a significant relationship between all variables, knowledge, comprehension and analysis as constructs of experiential learning and user-friendliness,

effectiveness, usability and satisfaction for the level of significance at the 0.01 level. The data indicate that the correlation between all variables is significant. This implies that the features of Android-based applications can improve the respondents' experiential learning level regarding these constructs. Android-based apps were used as a form of educational content that aided students in grasping and retaining the material. The features of these apps improve their experiential learning by giving them challenging tasks related to the material being taught. Learners will benefit from a richer educational experience when android applications are incorporated into the classroom.

Researchers and practitioners should remember that mobile learning helps positively impact students' academic achievement and performance; it can also increase their motivation to learn. In a study by Demir and Akpinar (2018), mobile learning can help students' academic achievement. Furthermore, the students consider mobile learning to keep them motivated. In addition, a study by Petrovic et al. (2014) shows that learning takes place in real-life situations. Students build and strengthen new abilities through already existing knowledge and gathering further information through observation.

5. Conclusion

This study finds a significant difference in students' learning experience before and after using android applications in knowledge, comprehension and evaluation. There is also a significant relationship between the experiential learning of science students and the features of Android Applications, thus, rejecting both the postulated hypothesis for the study. Since the study revealed substantial evidence of the effectiveness of android application in teaching and learning, specifically in the experiential knowledge of students, teachers may consider using Android Applications in teaching Science that includes learning activities suited to the topic and can give students the opportunities to improve the level of their experiential learning. Likewise, the school and school administration may encourage teachers to use an android application as instructional material to enhance the students' experiential learning. Furthermore, this study's replication using other variables that are not part of the study may be conducted to assess further the strength of the Android applications as to applicability and effectiveness.

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